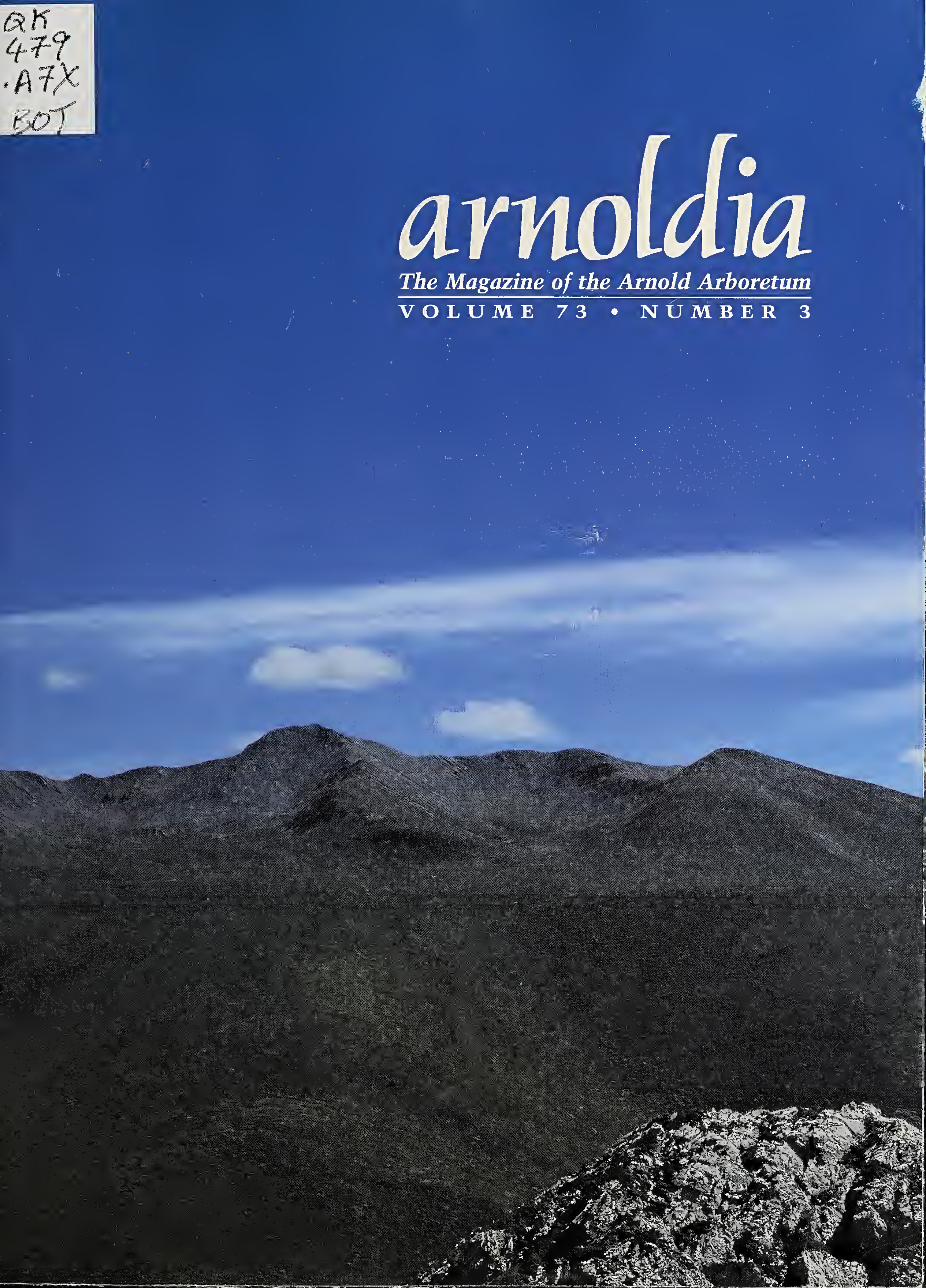
arnoldia

The Magazine of the Arnold Arboretum

VOLUME 73 • NUMBER 3



arnoldia

The Magazine of the Arnold Arboretum

VOLUME 73 • NUMBER 3 • 2016

Arnoldia (ISSN 0004–2633; USPS 866–100) is published quarterly by the Arnold Arboretum of Harvard University. Periodicals postage paid at Boston, Massachusetts.

Subscriptions are $20.00 per calendar year domestic, $25.00 foreign, payable in advance. Remittances may be made in U.S. dollars, by check drawn on a U.S. bank; by international money order; or by Visa, Mastercard, or American Express. Send orders, remittances, requests to purchase back issues, change-of-address notices, and all other subscription-related communications to Circulation Manager, *Arnoldia*, Arnold Arboretum, 125 Arborway, Boston, MA 02130-3500. Telephone 617.524.1718; fax 617.524.1418; e-mail arnoldia@arnarb.harvard.edu

Arnold Arboretum members receive a subscription to *Arnoldia* as a membership benefit. To become a member or receive more information, please call Wendy Krauss at 617.384.5766 or email wendy_krauss@harvard.edu

Postmaster: Send address changes to
Arnoldia Circulation Manager
The Arnold Arboretum
125 Arborway
Boston, MA 02130–3500

The ARNOLD ARBORETUM of HARVARD UNIVERSITY

CONTENTS

Front and back covers: Curator of Living Collections Michael S. Dosmann photographed this view of the Xueshan, or Snow Mountain Ridge, from the winding alpine road through Huanglong Nature Reserve during a plant collecting expedition in northern Sichuan Province, China, in September 2015.

Inside front cover: Ernest Henry Wilson photographed this Japanese linden (*Tilia japonica*) growing on the shore of Lake Chuzenji, Nikko, Japan, on May 29, 1914. Archives of the Arnold Arboretum.

Inside back cover: A mass planting of winter jasmine (*Jasminum nudiflorum*, accession 603-81) in bloom brightened the Explorers Garden in early January. Photo by Jon Hetman.

The ARNOLD ARBORETUM of HARVARD UNIVERSITY

CAMPAIGN FOR THE LIVING COLLECTIONS

Last autumn the Arnold Arboretum launched the Campaign for the Living Collections, an ambitious ten-year plan to expand the breadth of plant holdings and increase their scientific and horticultural value. Considerable thought and effort went into creating a document that guides the Campaign's mission. We present this important document here in its entirety for the benefit of Arboretum supporters, stakeholders, and colleagues. Additional articles covering aspects of developing our Living Collections will be featured in Arnoldia this year.

Developing an Exemplary Collection: A Vision for the Next Century at the Arnold Arboretum of Harvard University

William E. Friedman, Michael S. Dosmann, Timothy M. Boland, David E. Boufford, Michael J. Donoghue, Andrew Gapinski, Larry Hufford, Paul W. Meyer, and Donald H. Pfister

The Living Collections of the Arnold Arboretum of Harvard University not only support the Arboretum's mission by serving key research, education, and conservation roles, but in their entirety represent one of the very best examples of a historic Olmsted landscape. With some 15,000 accessioned plants, representing almost 4,000 unique taxa that include 2,100 species, the Living Collections of the Arnold Arboretum remain a major destination for those who study and enjoy woody plants. Of the accessions brought to the Arboretum from elsewhere, 44% are of wild origin, hailing from over 60 different temperate countries. Another 39% are of cultivated origin, including pedigreed hybrids, nursery-origin introductions, and accessions from other gardens. This historic interplay between taxonomic, floristic, and cultivated diversities has resulted in one of the most comprehensive and heavily documented collections of temperate woody plants in the world.

The living collections are central to the Arnold Arboretum—all research, education, and conservation initiatives are driven by them. And yet, without strategic planning for collections development, these collections are at risk of losing their prominence. In advance of the Arboretum's sesquicentennial in 2022, it is time to put forward a set of initiatives to simultaneously preserve its singular legacy and secure its future. This plan, to be enacted over the next decade, will thus serve to shape and define the Living Collections of the Arnold Arboretum for the coming century.

Values and Aspirations

Throughout the Arboretum's history, the vitality and strength of the collections—and the institution as a whole—can be attributed to an adherence to four essential tenets.

NANCY ROSE

The Arboretum's collection of *Malus* (apples and crabapples) currently holds 426 individual plants from 310 accessions comprising 159 taxa, many of which grow on Peters Hill, seen here.

It has remained a **traditional arboretum,** with the Living Collections continually and almost exclusively focused on temperate woody plants. It has been committed to **collections-based woody plant scholarship,** particularly in recent years with the significant expansion of on-site research associated with construction of the Weld Hill Research Building. The Arboretum landscape remains true to the vision of **Frederick Law Olmsted's design,** through keen awareness of its role as a public garden and landscape. Lastly, the Arnold Arboretum has long invested in **active curation and collections management,** which in turn has fostered and enabled its research and preservation enterprises.

Coupled to these principles are aspirations that the Living Collections Advisory Board (Tim Boland, David Boufford, Michael Donoghue, Larry Hufford, Paul Meyer, and Don Pfister), in collaboration with William (Ned) Friedman (Director), Michael Dosmann (Curator of Living Collections), and Andrew Gapinski (Manager of Horticulture), advanced during its 2013, 2014, and 2015 meetings. These recommendations to ambitiously strengthen the collections of the Arnold Arboretum articulate a set of guidelines that define targets for active collections development. In addition, these recommendations clearly circumscribe overarching principles that will help ensure that the Arnold Arboretum remains at the leading edge of botanical garden collections development.

Enacting the Agenda and Creating a List of Desiderata

Four principles will shape a unique identity for the Arboretum's ongoing and future roles in collections-based research, teaching, and public horticulture: (1) scholarship associated with comparative biology, from genomics to environmental change; (2) ex situ conservation and study of endangered temperate woody plant taxa; (3) strengthened species representation within key priority genera; and (4) successful cultivation of taxa currently or historically perceived as marginally hardy in Boston. Shared among these is the primary importance of a university-based organismic collection and public garden with the potential to uniquely reveal the complexities of nature. This deeply held notion expresses the intrinsic value that an individual accession or a suite of accessions possesses that enables a scholar to unravel (and share with the world) a taxon's mysteries. This extends to naturally occurring taxa as well as unique cultigens, honoring the Arboretum's long history of cultivating and comparing both, side-by-side. This core philosophy underpins all others.

In support of these priorities for collections development, six goals have been used to specifically create and prioritize a list of desiderata for acquisition and accessioning into the organismic collections of the Arnold Arboretum over the next decade (see page 15). These six goals

NANCY ROSE

ARNOLD ARBORETUM

The Arboretum's collections include both wild species and cultigens (plants whose origin or selection results primarily from intentional human activity). This specimen (left) of kousa dogwood (*Cornus kousa* 1079-89-C) was grown from seed wild collected in China during the Arboretum's 1989 Eastern China Expedition; at right, a variegated cultivar (*C. kousa* 'Snowboy' 507-82-A) that was originally selected at the Sakata Nursery Company in Yokohama, Japan.

reflect the importance of phylogenetic knowledge, organismic biology, conservation biology, genomics, and horticultural leadership to the future of the Arnold Arboretum.

1. **Increase "phylogenetic breadth" within clades**

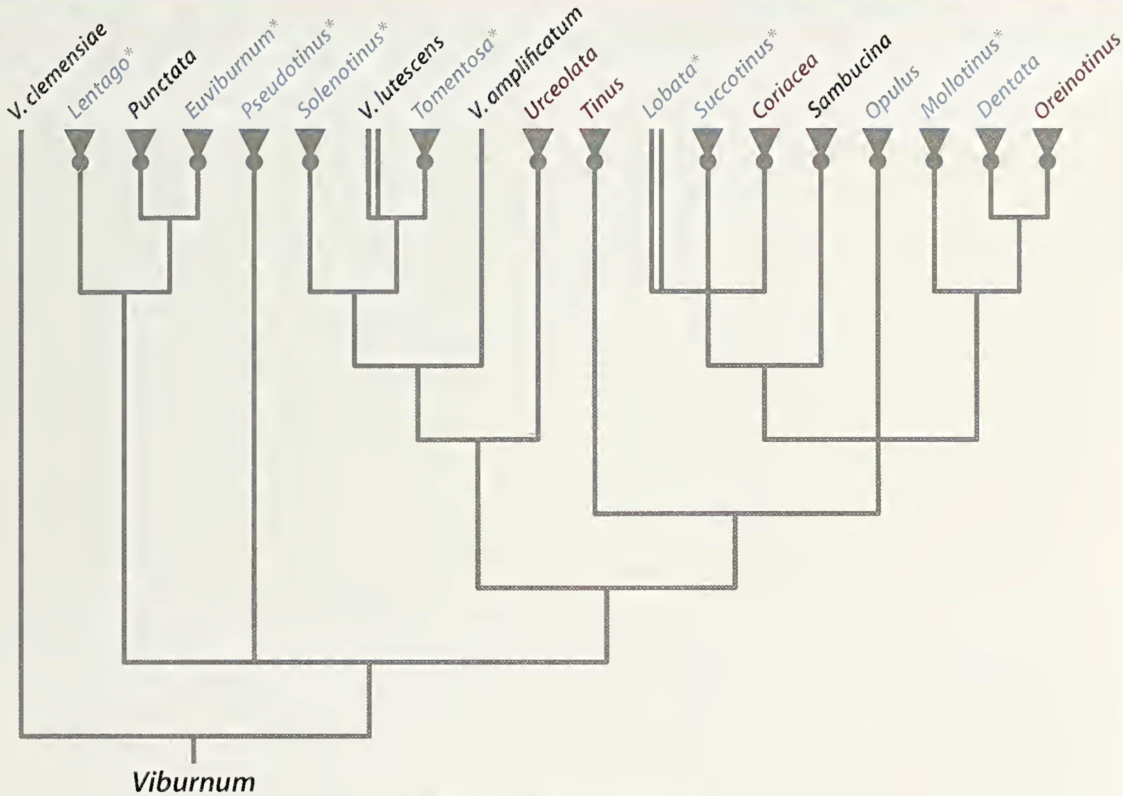
   The Arnold Arboretum will acquire new taxa that significantly expand the phylogenetic diversity of specific clades (evolutionary lineages). The modern explosion of phylogenetic information provides a key set of opportunities to ensure that the Arboretum acquires new taxa representative of as many of the major subclades of a genus or family as is practicable. Key families and genera that may be well represented in the Living Collections, as measured by total species numbers, may, in fact, lack critical exemplar species central to phylogenetic and comparative studies. This principle not only maximizes the potential for comparative evolutionarily grounded studies within and among diverse groups, but also serves as an organizing scheme for prioritized assembly of a synoptic collection.

2. **Increase "biological breadth" within clades**

   The Arnold Arboretum will acquire new taxa that significantly expand the biological diversity of specific clades. These include key additions of taxa with strongly divergent phenologies, structure (habit, morphology, anatomy), or physiological traits associated with adaptation to environments that differ from other members of a clade, such as evergreen taxa in clades historically represented only by deciduous taxa (or vice versa). Attention to biological (and phylogenetic) breadth will significantly improve scholarship opportunities associated with comparative research endeavors within a single botanical collection and expand the public's understanding of botanical and horticultural diversity within key genera and families of plants.

COURTESY OF ALAN CRESSLER

Conservation of rare and endangered species is a priority at the Arboretum. One example is bigleaf witch-hazel (*Hamamelis ovalis*), a North American species that was first identified in Mississippi in 2004.



Plant Phylogeny

When explaining the relatedness of organisms, scientists often construct a phylogeny, or "family tree," that portrays the organisms' evolutionary history. This figure depicts taxa (such as species, genera, families, etc.) on the tips or ends of the branches. Each taxon placed at the end of a branch is paired with its closest relative; the two can be traced back to a shared node that represents their common ancestor. That branch, in turn, can be traced back further to another ancestor that is common to it and another "sister" branch, ad infinitum. A branch that includes the common ancestor and all of its descendants is referred to as a clade. In contemporary phylogenetic systematics, a plant family's phylogeny should comprise individual clades of species that form distinct genera. Genera themselves comprise clades of species that share a common ancestor, and may receive special names.

Organizing related species into clades is useful when studying large genera and families, particularly if the group is supported by a well-developed and accepted phylogeny. In such cases scientists look at all of the clades that occur across the breadth of the phylogeny but only need to sample one or two species per clade. We have taken the same approach to collections development at the Arboretum, where comprehensive or total species composition within a genus is not a goal but phylogenetic breadth (i.e., representation of as many clades as possible) is.

The genus *Viburnum* (comprising some 165 species) is one such example. Decades of work in Michael Donoghue's laboratory has yielded a well-supported *Viburnum* phylogeny containing 19 terminal clades of closely related species (above, modified from Clement et al. 2014). Ten of these clades (shown in blue) are already represented in the Arboretum's collections by at least one species; acquisition of a few more species (*) improves their representation. Although the remaining clades contain species not suited to New England (most are tropical), four clades (shown in red) contain a few marginally-hardy species that are worth trialing. Adding even just one species from a clade (e.g., *V. davidii* in the Tinus Clade) adds a completely new evolutionary lineage to the collections.

Clement, W. L., M. Arakaki, P. W. Sweeney, E. J. Edwards, and M. J. Donoghue. 2014. A chloroplast tree for *Viburnum* (Adoxaceae) and its implications for phylogenetic classification and character evolution. *American Journal of Botany* 101: 1029–1049.

3. **Create a unique identity in conservation biology**

   With continued threats to Earth's biodiversity, the need to provide safe harbor to taxa under threat of extinction is as important today as it has ever been. However, while seed banks and other germplasm repositories may well preserve threatened and extinct-in-the-wild taxa, only living accessions of such taxa can be studied to reveal the biology within. The Arnold Arboretum is uniquely suited to acquire threatened temperate woody plants, cultivate them, develop essential propagation protocols, disseminate them to others, and conduct research into their basic biology. Beyond the innate value of generating new knowledge of biodiversity, effective ecological restoration depends on a sophisticated understanding of the basic and applied biology of threatened taxa.

4. **Create a unique identity in woody plant genomics**

   For centuries, type specimens (pressed and dried plant parts) associated with the specific living organism on which a species description was first made have been deposited in herbaria around the world. In the emerging age of genomics, the Arnold Arboretum will become the first botanical garden to officially steward the living germplasm of diverse species for which detailed genomic information has been collected and published (the Arboretum will obviously focus only on temperate woody plants). Already, some of the key germplasm for genomic analysis of woody plants has been lost in the wild and exists only in tissue culture or short-term nursery operations, where biological study is not possible. Creating a "living type specimen collection" for species whose genomes have been sequenced and assembled will ensure that all future studies of the biology of such species will have access to the actual plant/germplasm with the specific allelic complement in the published genome.

5. **Prioritize acquisition of taxa within geographically disjunct clades**

   Within the Living Collections of the Arnold Arboretum, the floras of eastern North America and eastern Asia have long been extremely well represented. Yet, to maximize the Living Collections' further application toward the study of biogeog-

WILLIAM E. FRIEDMAN

WILLIAM E. FRIEDMAN

***Catalpa* is a disjunct genus with similar looking species growing in eastern Asia and eastern North America. Seen here are Chinese catalpa (*C. ovata* 237-2002-B, left) and northern catalpa (*C. speciosa* 1245-79-C, right), a North American species.**

Genome Sequencing Brings New Knowledge

Genome sequencing, which allows the entire string of DNA code to be read and interpreted for almost any species on earth, has the potential to link specific biological characteristics to specific genes and their genetic variants. Fifteen years ago, it cost nearly $100 million to sequence a genome and today, this cost is rapidly approaching $1,000. Thus, in the last decade, woody plant species as diverse as grape, poplar, pine, willow, oak, and birch have had their genomes sequenced, so that their biological traits can be related directly to their genes. Many more species of trees, shrubs, and lianas are in the pipeline for genomic sequencing.

In the spring of 2015, the Arnold Arboretum hosted an international symposium on the genomics of forests and trees that brought together 80 of the leading scholars in this emerging world of DNA information. One critical challenge that came up repeatedly in discussions with participants is that those organisms whose genomes have been or are going to be sequenced are at high risk of being lost since there is no formal plan for perpetual stewardship. Incredibly, there is no home in the entire world for the unique individual plants whose genomes have been sequenced.

The Arnold Arboretum has a perfect combination of world-class horticulture and world-class laboratory facilities to pioneer a "genomic type collection" of temperate woody plants, and will care in perpetuity for these incredibly special individual plants whose genomes have been sequenced. This genomic type reference collection will help tell us how trees will respond to climate change, how water moves from the soil to the top of the crown, how plants respond to biotic (herbivores) and abiotic (climate extremes) stresses. As research comes to rely more heavily on sequenced genes to advance discovery, the ability to reference the living counterpart of this DNA—either through the plant itself or its direct lineage—will make the Arnold Arboretum an essential resource for this work.

raphy, ecophysiology, and phylogenetics, acquiring disjunct species associated with clades of eastern North American woody plants will be a priority. Although the majority of these disjunct taxa are of Asian origin, disjunct taxa from Europe and the Southern Hemisphere (although fewer in number) will also be sought.

6. **Reassert horticultural leadership in accessioning marginally hardy species**

   As established at its founding in 1872, the Arboretum will cultivate "all the trees, shrubs, and herbaceous plants, either indigenous or exotic, which can be raised in the open air." In the spirit of exploration and experimentation, the Arboretum has continually acquired germplasm of marginally hardy taxa to be coaxed into cultivation, despite and against all odds. To ensure that the Arboretum stays at the cutting edge of plant introduction (especially in a world of rapid environmental change), it must seek out, acquire, and test untried species for growth on the grounds. Importantly, identification of new "marginal" taxa should be coupled with targeted field collections of germplasm from parts of the taxon's natural range that are likely to predispose such accessions to ultimate success on the grounds. In light of predicted climate change scenarios over the next century in Massachusetts, the marginally hardy taxa of today are likely to be well positioned to grow and thrive at the Arnold Arboretum in the future.

With all of this in mind, a list of desiderata comprising roughly 400 separate taxa has been developed, where each target for acquisition falls into one and often multiple prioritized categories or themes based on the guiding prin-

The Arboretum will acquire and trial marginally hardy species such as *Daphniphyllum macropodum* (left; seen growing at the Morris Arboretum in Philadelphia) from eastern Asia and *Osmanthus americanus* (right), which is native to the southern United States.

ciples above (Table 1). With this target list, the immediate goal is to obtain one new lineage of each taxon. However, in the longer term most targeted taxa will require multiple acquisitions from varying parts of their ranges to ensure broad genetic representation. All taxa on the list are to come from documented wild populations. This will result in as many as 700 unique acquisitions and eventually some 2,500 accessioned plants (assuming all new marginally hardy taxa survive on the grounds). The individuals on the list represent taxa that the Arboretum has never attempted to grow, those attempted in the past yet worthy of further efforts (especially in light of climate change and a far more sophisticated understanding of the microclimates of the Arboretum grounds), as well as those represented yet insufficiently. It should also be noted that this list of desiderata reflects, almost exclusively, botanical taxa. In time, attention should be placed on prudent review and development within cultivar collections. Importantly, the listed taxa represent specific priorities, not a limited scope for all future acquisitions.

Acquisition of New Plant Material and an Underlying Collaborative Philosophy

The aspirations of this plan to develop an exemplary collection at the Arnold Arboretum of Harvard University require a disciplined commitment to actuate collections expeditions, work with scholars in the field who can collect on behalf of the Arboretum, and employ contract collectors as needed. In particular, the Arnold Arboretum will leverage the deep and historical relationships with China, Japan, and Korea to mount a series of collecting expeditions to acquire new species and extend population sampling of currently held taxa. In turn, the leadership in propagation and horticultural operations at the Arnold Arboretum will be charged with bringing the world's temperate woody flora from propagules to century-long inhabitants on the grounds. The current assemblage of what may prove to be the finest team of horticultural leaders in the Arboretum's history provides strong motivation to seek out woody taxa from around the world that are not currently in cultivation at the Arboretum.

Table 1. High-priority targets for future acquisition comprise 395 separate taxa that represent 385 species among 145 distinct genera (see List of Desiderata). Each distinct target is linked to one or more of the priority goals put forward by the Collections Advisory Board. This table summarizes those core themes and other basic statistics.

New species for the collections	177
marginally hardy	92
New genera for the collections	41
marginally hardy	31
Taxa already represented in the collection by living lineages	218
… but not of wild provenance	97
… of wild provenance but requiring additional wild lineages[z]	121
Principal categories[y]:	
Conservation concern[x]	51
PCN genera[w]	114
Robust genera[v]	12
Disjunct genera[u]	47
Acquisition targets' regions of origin:	
Eastern Asia	225
Eurasia	18
Europe	17
North America	133
South America	2

[z] Includes taxa where numerous wild-origin lineages are required, often for conservation purposes, or to repatriate known Arboretum lineages from other repositories and gardens.

[y] Categories are not mutually exclusive; many target species occur in multiple categories.

[x] Those taxa to which a conservation ranking has been given.

[w] Plant Collections Network: *Acer, Carya, Fagus, Stewartia, Syringa,* and *Tsuga*

[v] *Carpinus, Forsythia, Ginkgo,* and *Ostrya*

[u] Only pertains to species occurring in *Cornus, Diervilla/Weigela, Hamamelis, Hydrangea, Magnolia, Taxus,* and *Viburnum*

CUI ZHIJAO

Michael Dosmann (Arnold Arboretum) and Anthony S. Aiello (Morris Arboretum) work with Wang Kang of the Beijing Botanical Garden collecting seeds from *Fraxinus chinensis* in the mountains west of Beijing, China, during the September 2010 North America–China Plant Exploration Consortium expedition.

Central to the mission of acquiring hundreds of new specimens for the living museum and grounds of the Arnold Arboretum is a historical commitment to collaboration and sharing. Such collaborations are two-fold in nature. First, there is the need to establish joint ventures between the Arnold Arboretum and botanical and horticultural institutions around the world to collect germplasm. This is especially critical in Asia, where local and national permissions will depend on true cooperation, sharing, and reciprocity. Second, it will be vitally important to work with a set of similar institutions and consortia (e.g., the North America-China Plant Exploration Consortium) that can help steward newly acquired plant materials and ultimately share these acquisitions with scientists and the public. Such sharing of germplasm with similar institutions in the United States will be particularly important to maximize the success of ex situ conservation efforts, given that many of the taxa collected may be marginally hardy in Boston.

In summary, integrating the core values that have yielded the Arboretum's greatest legacy with six bold aspirational concepts will extend the importance and impact of the Arboretum's organismic collections well into the future. Change in the Living Collections occurs incrementally over time, with each new accession added, and with each deaccession as well. As seasons turn into years, and years into decades, the ambitions and goals the Arboretum establishes now will truly bear fruit. At its bicenten-

JON HETMAN

Kyle Port, the Arboretum's manager of plant records, affixes permanent plant labels to a specimen heading to the grounds for spring planting.

WILLIAM E. FRIEDMAN

WILLIAM E. FRIEDMAN

The *Carya* collection is one of six Plant Collections Network collections currently at the Arboretum. Seen here, fruits of shagbark hickory (*C. ovata* 22868-N) and bud scales and new shoots of shellbark hickory (*C. laciniosa* 806-87-C).

nial in 2072, the Arboretum community will be able to look back and pinpoint this campaign as one that guaranteed and secured a future where the Arnold Arboretum became the single most important living collection for those who study and enjoy temperate woody plants.

Developing an Exemplary Collection—Metrics and a List of Desiderata

Over the past decade, the total number of deaccessions has significantly exceeded the total number of new accessions planted at the Arnold Arboretum. On average each year, roughly 250 new accessions are successfully added to the collections. In order to achieve the goals described in this plan to secure the long term preeminence of the Living Collections of the Arnold Arboretum, acquisition and successful propagation of new and diverse germplasm will dominate the early phases of this campaign. The second phase of this ambitious program will then leverage the accomplishments of plant production efforts to move new accessions onto the grounds. We anticipate that at the peak of this second phase close to 300 new accessions will be added to the permanent Living Collections annually. The new leadership in collections-based horticulture (Andrew Gapinski) and in plant production (Tiffany Enzenbacher), along with the recent significant improvement in the management and job circumscriptions of horticulturists charged with the day-to-day care of the living collections, will ensure that this plan is successful. The horticultural team will be charged, under the leadership of the Curator of Living Collections (Michael Dosmann) and Director (William Friedman), with the creation of a specific set of plans and targets to fully enact the vision of this decadal campaign for the next century of the Arnold Arboretum's history.

List of Desiderata: Priority Genera (Plant Collections Network, Robust, and Disjunct Genera)

Highlighted are 17 genera that will receive focused investment in review and future acquisition. In fact, over 40% of the listed taxa are within this group. Although the collection goals for each of these are similar, there are some subtle differences in the levels at which each target should be represented.

Plant Collections Network (PCN) genera (*Acer, Carya, Fagus, Stewartia, Syringa,* and *Tsuga*)

These six PCN collections are of national renown and highlighted as exemplary collections emblematic of the Arboretum. Species diversity within each genus is to be comprehensive, not synoptic, with each species represented by at least one wild-origin lineage in the short term, and eventually by at least three distinct wild-origin lineages from a broad portion of the species' range.

Robust genera (*Forsythia, Carpinus, Ostrya,* and *Ginkgo*)

During the 2014 meeting of the Collections Advisory Board, a proposal was approved to recognize a new set of priority genera. Three of these (*Carpinus, Forsythia,* and *Ostrya*) have historically been well represented, and extra emphasis can transform them from strong to exceptional collections. The goal for these is to achieve comprehensive species representation, with each species exemplified by at least one wild-origin lineage. A fourth genus (*Ginkgo*) deserves recognition as the most notable of its kind in cultivation, due primarily to the decades-long efforts by emeritus Arboretum scientist Peter Del Tredici. Although it is unlikely that wild populations exist other than those from which the Arboretum has already sampled, there remain gaps that can further improve the Arboretum's collection. The specific goals include the identification and acquisition of cultigens or landraces that further broaden the infraspecific diversity of *Ginkgo biloba*. In the immediate future, the Arboretum should propose that its *Ginkgo* collection be included in the PCN.

Disjunct genera (*Cornus, Hamamelis, Magnolia, Hydrangea sensu lato, Taxus, Diervilla/Weigela,* and *Viburnum*)

The rich evolutionary history shared between the floras of Eastern Asia and North America has also been an important part of the Arnold Arboretum's history. Although the list of desiderata identifies many genera (including many of those listed above) that are referred to as disjuncts, there are seven genera (*Cornus, Hamamelis, Magnolia, Hydrangea sensu lato, Taxus, Diervilla/Weigela,* and *Viburnum*) specifically prioritized for active development because of this distinction. Species representation should remain synoptic (although *Hamamelis* is already represented at the comprehensive level), with priority based on the axes of conservation status and phylogenetic breadth. Each species should be represented by at least one wild-origin lineage.

Filling in Synoptic and Documentation Gaps

Beyond the focused development of the 17 genera above, many other species must be added to achieve the stated goals. If the Arboretum's

MICHAEL S. DOSMANN

***Croton alabamensis*, a rare semi-evergreen shrub, is one of the species the Arboretum plans to acquire.**

Living Collections are to be considered fully synoptic and representative of Earth's temperate woody flora, over 175 species and 40 genera not represented will be targeted and acquired. Acquisition of the rare is essential, and the list of desiderata includes over 50 targets with specific conservation value as measured by a NatureServe ranking of G1 to G3 (critically imperiled, imperiled, vulnerable) or its general equivalent.

Documentation is the most reliable predictor of accession value, and many targets were selected to fill documentation gaps. One-fourth of the target taxa on the list are already growing in the Living Collections, yet are represented by accessions that are not of wild origin. It is essential that these "finally wild" targets are integrated into the Living Collections to displace specimens that have poorer (or no) documentation. Another third of the target taxa already exist in the collections and include at least one wild-origin accession. However, additional wild lineages are required to broaden the diversity of that taxon's lineage pool. An additional one-fourth of the target taxa either have not been tried at the Arboretum in the past, or they were planted but failed to establish because they were not sited in a suitable microclimate or for other reasons. In the spirit of exploration, hardiness testing, and plant introduction, the Arboretum will trial these taxa.

MICHAEL S. DOSMANN

MICHAEL S. DOSMANN

Ostryopsis davidiana (top) and _Acer caudatum_ ssp. _multiserratum_ (bottom) are among the species on the list of desiderata. The specimens seen here were photographed in China during the 2010 NACPEC expedition.

Genomic Type Specimens

Initially, the number of accessions associated with published genomic data will likely number in the single digits. However, with time, improvements in DNA sequencing technology and data analysis will likely yield dozens, if not hundreds of temperate woody plant taxa with sequenced genomes. The Living Collections Advisory Board will be charged with assessing which taxa should be added to the genomic type specimens of the Arboretum. Initially, attention to phylogenetic breadth

YIN KAIPU

Collaboration between the United States and China is key to the Arboretum's goal to strengthen the conservation and study of plants. On September 28, 2015, the Huanglong Nature Reserve (a UNESCO World Heritage Site), the Chengdu Institute of Biology of the Chinese Academy of Sciences, and the Arnold Arboretum established a memorandum of understanding that sets guidelines for cooperation in the documentation, conservation, and preservation of plants native to China's richly biodiverse Sichuan Province. The trilateral agreement was signed in Chengdu by Huanglong Nature Reserve Director Qi Ling (left), Arnold Arboretum Director William (Ned) Friedman (center), and Chengdu Institute of Biology Director Xinquan Zhao (right).

both within angiosperms and also across seed plants (e.g., conifers and gnetophytes) should be critical. However, with time, opportunities for focused comparative biological studies of genomic type specimens from multiple species (or even populations) within a species/genus/clade are likely to become important.

Concluding Thoughts

The Campaign for the Living Collections does not just consider the long term, it focuses on it. The 400 taxa to be acquired in the next ten years, including 177 species of woody plants new to the grounds of the Arnold Arboretum, will have a profound impact on the character and value of the living collections. This impact will resonate for decades, if not centuries, to come, just like the vital collections made a century ago by explorers like Sargent, Wilson, Rock, and countless others. The efforts of this decade-long campaign are aimed at renewing and reinventing the Arboretum's legacy of discovery, natural history, and plant collecting to document, preserve, and study biodiversity in a world dominated by human-induced habitat loss and climate change.

William E. Friedman is Director of the Arnold Arboretum and Arnold Professor of Organismic and Evolutionary Biology at Harvard University; Michael S. Dosmann is Curator of Living Collections at the Arnold Arboretum; Timothy M. Boland is Executive Director of Polly Hill Arboretum; David E. Boufford is Senior Research Scientist at the Harvard University Herbaria; Michael J. Donoghue is Curator of Botany at the Peabody Museum and Sterling Professor of Ecology and Evolutionary Biology at Yale University; Andrew Gapinski is Manager of Horticulture at the Arnold Arboretum; Larry Hufford is Professor and Director of the School of Biological Sciences and Director of the Marion Ownbey Herbarium at Washington State University; Paul W. Meyer is F. Otto Haas Executive Director of the Morris Arboretum of the University of Pennsylvania; and Donald H. Pfister is Curator of the Farlow Library and Herbarium and Asa Gray Professor of Systematic Botany at Harvard University.

List of Desiderata

Family	Taxon
Actinidiaceae	*Actinidia chinensis*
Adoxaceae	*Viburnum atrocyaneum* *Viburnum bracteatum* *Viburnum buddleifolium* *Viburnum carlesii* *Viburnum cylindricum* *Viburnum davidii* *Viburnum ellipticum* *Viburnum farreri* *Viburnum foetidum* *Viburnum ichangense* *Viburnum kansuense* *Viburnum lantanoides* *Viburnum microcarpum* *Viburnum mongolicum* *Viburnum obovatum* *Viburnum plicatum* ssp. *tomentosum* *Viburnum sieboldii* *Viburnum tinus* *Viburnum urceolatum* *Viburnum wilsonii*
Altingiaceae	*Liquidambar styraciflua*
Anacardiaceae	*Cotinus szechuanensis*
Apocynaceae	*Asclepias incarnata* *Trachelospermum difforme*
Araliaceae	*Aralia nudicaulis*
Araucariaceae	*Araucaria araucana*
Aristolochiaceae	*Aristolochia tomentosa*
Berberidaceae	*Nandina domestica*
Betulaceae	*Alnus glutinosa* *Alnus maritima* *Betula alleghaniensis* *Betula alnoides* *Betula chichibuensis* *Betula humilis* *Betula lenta* *Betula luminifera* *Betula maximowicziana* *Betula murrayana* *Betula pumila* *Betula schugnanica* *Betula uber* *Carpinus caroliniana* *Carpinus cordata* *Carpinus coreana* *Carpinus henryana* *Carpinus polyneura* *Ostrya japonica* *Ostryopsis davidiana*
Bignoniaceae	*Campsis grandiflora*
Buxaceae	*Pachysandra procumbens* *Pachysandra terminalis* *Sarcococca hookeriana* var. *digyna*
Cactaceae	*Opuntia humifusa*
Cannabaceae	*Aphananthe aspera* *Celtis tenuifolia*
Caprifoliaceae	*Kolkwitzia amabilis* *Leycesteria formosa* *Weigela coraeensis* *Weigela maximowiczii* *Weigela middendorffiana*
Celastraceae	*Euonymus fortunei* *Euonymus obovatus*
Cercidiphyllaceae	*Cercidiphyllum magnificum*
Cloranthaceae	*Sarcandra glabra*
Cornaceae	*Alangium platanifolium* *Aucuba japonica* *Cornus alternifolia* *Cornus canadensis* *Cornus florida* *Cornus foemina* *Cornus nuttallii* *Cornus quinquinervis* *Cornus rugosa*
Cupressaceae	*Cupressus nootkatensis*
Cyrillaceae	*Cliftonia monophylla*
Daphniphyllaceae	*Daphniphyllum macropodum*
Elaeagnaceae	*Elaeagnus multiflora*
Ephedraceae	*Ephedra distachya* *Ephedra equisetina* *Ephedra gerardiana* *Ephedra intermedia* *Ephedra likiangensis* *Ephedra major* *Ephedra minuta* *Ephedra monosperma* *Ephedra przewalskii* *Ephedra rituensis* *Ephedra sinica* *Ephedra viridis*
Ericaceae	*Agarista populifolia* *Eubotryoides grayana* *Gaultheria miqueliana* *Gaultheria procumbens* *Kalmia cuneata*

Family	Taxon
	Kalmia latifolia
	Pieris floribunda
	Pieris formosa
	Pieris japonica
	Rhododendron maximum
	Rhododendron smirnowii
	Vaccinium angustifolium
	Vaccinium macrocarpon
Euphorbiaceae	*Croton alabamensis*
Fabaceae	*Cercis siliquastrum*
	Cladrastis kentuckea
	Cladrastis wilsonii
	Gymnocladus chinensis
	Maackia hupehensis
	Robinia hispida
Fagaceae	*Fagus crenata*
	Fagus engleriana
	Fagus grandifolia
	Fagus hayatae
	Fagus japonica
	Fagus longipetiolata
	Fagus lucida
	Fagus moesiaca
	Fagus multinervis
	Fagus orientalis
	Fagus sylvatica
	Nothofagus dombeyi
	Quercus acerifolia
	Quercus castaneaefolia
	Quercus falcata
	Quercus frainetto
	Quercus gambelii
	Quercus imbricaria
	Quercus nigra
	Quercus prinoides
	Quercus velutina
Ginkgoaceae	*Ginkgo biloba*
Hamamelidaceae	*Disanthus cercidifolius*
	Distylium racemosum
	Fortunearia sinensis
	Fothergilla gardenii
	Fothergilla major
	Hamamelis japonica
	Hamamelis mollis
	Hamamelis ovalis
	Hamamelis vernalis
	Parrotiopsis jacquemontiana
	Sinowilsonia henryi
	Sycopsis sinensis
Helwingiaceae	*Helwingia japonica*
Hydrangeaceae	*Cardiandra alternifolia*
	Cardiandra moellendorfii
	Decumaria sinensis
	Deinanthe bifida
	Hydrangea macrophylla 'Ayesha'
	Philadelphus lewisii
	Platycrater arguta
Hypericaceae	*Hypericum beanii*
	Hypericum buckleyi
	Hypericum kalmianum
	Hypericum prolificum
Iteaceae	*Itea ilicifolia*
	Itea virginica
Juglandaceae	*Carya aquatica*
	Carya cathayensis
	Carya cordiformis
	Carya floridana
	Carya illinoinensis
	Carya laciniosa
	Carya myristiciformis
	Carya ovata
	Carya ovata var. *australis*
	Carya pallida
	Carya texana
	Carya tomentosa
	Juglans mandshurica
	Juglans nigra
Lamiaceae	*Monarda didyma*
	Prunella vulgaris
Lardizabalaceae	*Decaisnea fargesii*
Lauraceae	*Neolitsea sericea*
	Persea borbonia
	Sassafras albidum
	Sassafras tzumu
Liliaceae	*Lilium regale*
Lythraceae	*Lagerstroemia indica*
Magnoliaceae	*Liriodendron chinense*
	Magnolia acuminata
	Magnolia denudata var. *denudata*
	Magnolia figo
	Magnolia omeiensis
	Magnolia patungensis
Meliaceae	*Cedrela sinensis*
Menispermaceae	*Menispermum canadense*
	Menispermum dauricum
Moraceae	*Maclura pomifera*
Nyssaceae	*Davidia involucrata*
	Nyssa sinensis

Family	Taxon
Oleaceae	*Chionanthus virginicus*
	Forsythia europaea
	Forsythia japonica
	Forsythia mandschurica
	Forsythia suspensa
	Forsythia togashii
	Fraxinus americana
	Fraxinus nigra
	Fraxinus pennsylvanica
	Fraxinus quadrangulata
	Osmanthus americanus
	Syringa afganica
	Syringa emodi
	Syringa josikaea
	Syringa julianae
	Syringa komarowii
	Syringa komarowii ssp. *reflexa*
	Syringa mairei
	Syringa meyeri
	Syringa oblata
	Syringa oblata ssp. *dilatata*
	Syringa pinetorum
	Syringa pinnatifolia
	Syringa protolaciniata
	Syringa pubescens ssp. *microphylla*
	Syringa reticulata
	Syringa sweginzowii
	Syringa tibetica
	Syringa villosa
	Syringa vulgaris
	Syringa wardii
	Syringa yunnanensis
Papaveraceae	*Meconopsis integrifolia*
Pinaceae	*Abies alba*
	Abies koreana
	Larix laricina
	Larix lyalii
	Larix occidentalis
	Larix potaninii
	Picea abies
	Picea omorika
	Pinus albicaulis
	Pinus cembra
	Pinus lambertiana
	Pinus monophylla
	Pinus virginiana
	Pseudolarix amabilis
	Tsuga canadensis
	Tsuga caroliniana
	Tsuga chinensis
	Tsuga diversifolia
	Tsuga dumosa
	Tsuga forestii
	Tsuga formosana
	Tsuga heterophylla
	Tsuga mertensiana
	Tsuga sieboldii
Platanaceae	*Platanus orientalis*
Ranunculaceae	*Clematis akebioides*
	Clematis tangutica
	Clematis viridis
Rhamnaceae	*Ziziphus jujuba*
Rosaceae	*Amelanchier nantucketensis*
	Crataegus distincta
	Crataegus harbisonii
	Crataegus latebrosa
	Crataegus perjucunda
	Crataegus phaenopyrum
	Cydonia oblonga
	Exochorda korolkowii
	Exochorda racemosa
	Exochorda serratifolia
	Malus angustifolia
	Malus coronaria
	Malus florentina
	Malus ioensis
	Malus komarovii
	Malus prunifolia
	Malus transitoria
	Mespilus canescens
	Neviusia albamensis
	Physocarpus opulifolius
	Prunus apetala
	Prunus cyclamina
	Prunus maritima
	Prunus sargentii
	Rosa chinensis
	Rosa hugonis
	Rubus paludivagus
	Rubus prosper
	Rubus saltuensis
	Sorbaria kirilowii
	Sorbus domestica
	Sorbus wilsoniana
	Spiraea sargentiana
Rubiaceae	*Adina rubella*
	Emmenopterys henryi
	Mitchella undulata
Salicaceae	*Populus grandidentata*
	Populus tremuloides
	Salix jejuna
	Salix turnorii
Santalaceae	*Buckleya angulosa*
	Buckleya distichophylla

Family	Taxon
	Buckleya graebneriana
	Buckleya henryi
	Buckleya lanceolata
Sapindaceae	*Acer argutum*
	Acer buergerianum
	Acer caesium
	Acer campbellii
	Acer capillipes
	Acer cappadocicum
	Acer cappadocicum ssp. *divergens*
	Acer cappadocicum ssp. *lobelii*
	Acer caudatum
	Acer ceriferum
	Acer circinatum
	Acer cordatum
	Acer davidii ssp. *grosseri*
	Acer diabolicum
	Acer distylum
	Acer erianthum
	Acer fabri
	Acer fulvescens
	Acer glabrum
	Acer gracilifolium
	Acer griseum
	Acer heldreichii
	Acer henryi
	Acer hyrcanum
	Acer leipoense
	Acer longipes
	Acer lungshengense
	Acer macrophyllum
	Acer maximowiczianum
	Acer miyabei
	Acer mono ssp. *okamotoanum*
	Acer nipponicum
	Acer oblongum
	Acer oliverianum
	Acer opalus
	Acer pilosum
	Acer platanoides
	Acer pseudoplatanus
	Acer pubipalmatum
	Acer pycnanthum
	Acer robustum
	Acer rubrum
	Acer sempervirens
	Acer shirasawanum
	Acer sieboldianum
	Acer stachyophyllum
	Acer sutchuensense
	Acer tataricum ssp. *aidzuense*
	Acer tataricum ssp. *semenovii*
	Acer tenellum
	Acer truncatum
	Acer tschonoskii
	Acer tsinglingense
	Dipteronia sinensis
Schisandraceae	*Kadsura heteroclita*
	Kadsura japonica
	Schisandra glabra
Sciadopityaceae	*Sciadopitys verticillata*
Simaroubaceae	*Leitneria floridana*
Stachyuraceae	*Stachyurus chinensis*
Styracaceae	*Halesia macgregorii*
	Sinojackia henryi
	Sinojackia xylocarpa
	Styrax americanus
	Styrax grandifolius
Tamaricaceae	*Tamarix ramosissima*
Taxaceae	*Taxus brevifolia*
	Taxus wallichiana var. *chinensis*
	Taxus wallichiana var. *mairei*
	Torreya nucifera
Tetracentronaceae	*Tetracentron sinensis*
Theaceae	*Gordonia lasianthus*
	Schima wallichii
	Stewartia malacodendron
	Stewartia monadelpha
	Stewartia ovata
	Stewartia pseudocamellia
	Stewartia rubiginosa
	Stewartia serrata
	Stewartia sinensis
Thymeliaceae	*Daphne genkwa*
	Daphne mezereum
	Daphne tangutica
	Dirca decipiens
Tiliaceae	*Tilia henryana*
	Tilia kiusiana
Ulmaceae	*Planera aquatica*
	Ulmus alata
Ulmaceae	*Ulmus laevis*
	Ulmus macrocarpa
	Ulmus rubra
	Zelkova carpinifolia
	Zelkova serrata
Verbenaceae	*Callicarpa americana*
	Callicarpa bodinieri

Legacy Trees of Ernest Henry Wilson and John George Jack in Nikko, Japan

Mineaki Aizawa and Tatsuhiro Ohkubo

Nikko, in Tochigi Prefecture, about 80 miles (130 kilometers) north of Tokyo, has been among the most famous resorts in Japan for foreign visitors since the Meiji era (1868–1912). Nikko area attractions include Nikko National Park, Yumoto (a hot spring resort), Lake Chuzenji, and a number of shrines and temples. Two plant collectors from the Arnold Arboretum, Ernest Henry Wilson and John George Jack, traveled in Japan on separate trips in the early 1900s and both visited Nikko. In addition to collecting seeds and herbarium specimens for the Arboretum on their trips, the botanists made hundreds of photographs, which are now

Japanese larch (*Larix kaempferi*) near Yumoto, Nikko, on October 16, 1914, photographed by E. H. Wilson (AEE-03667 from the Arnold Arboretum Archives).

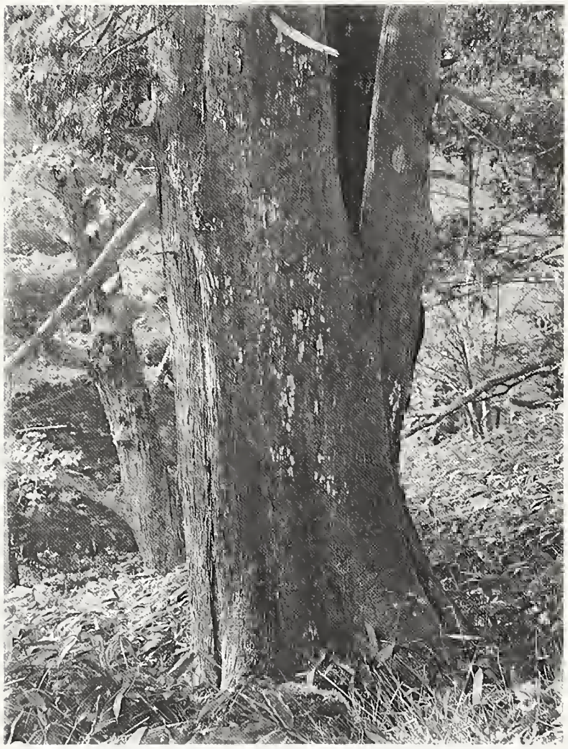
M. AIZAWA

The same *Larix kaempferi* on September 9, 2009.

Japanese arborvitae (*Thuja standishii*) near Yumoto, Nikko, on October 16, 1914, photographed by E. H. Wilson (AEE-03654 from the Arnold Arboretum Archives).

M. AIZAWA

The same Japanese arborvitae (*Thuja standishii*) on December 21, 2008.



***Thuja standishii* near Yumoto, Nikko, on October 16, 1914, photographed by E. H. Wilson (AEE-03655 from the Arnold Arboretum Archives).**

M. AIZAWA

The same Japanese arborvitae (*Thuja standishii*) on September 27, 2009.

available online in the digital archives of the Arnold Arboretum (directions for searching the database can be found at: http://www.arboretum.harvard.edu/library/image-collection/botanical-and-cultural-images-of-eastern-asia/search-the-image-database/).

E. H. Wilson visited Japan in 1914 and traveled throughout the country. According to his itinerary, he visited Nikko and photographed its trees and landscapes in May and October of that year. In 1905, nearly a decade before Wilson's visit, J. G. Jack also stayed in Nikko. He was interested in natural forests and forestry in Japan, and his photographs thus give us a glimpse into the forestry and lumber industries of Japan at that time.

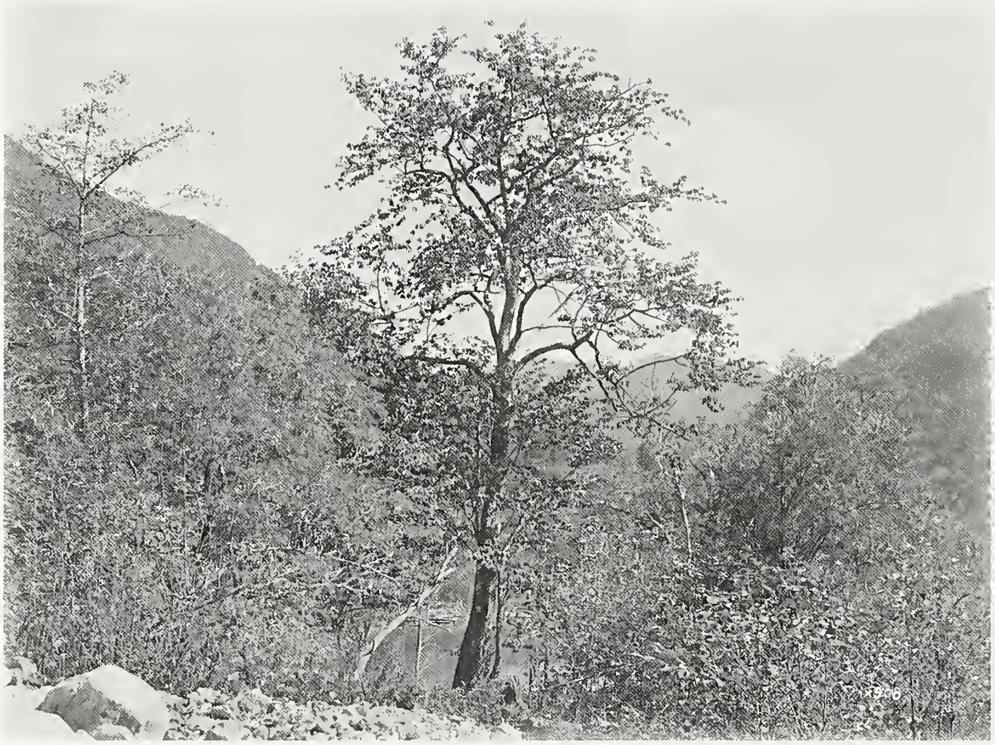
From 2007 to 2015, we traced the footprints of these visitors, and in some places we encountered the trees as Wilson and Jack had seen them in the past; the trees have kept their living witness for over a hundred years. We present here comparison photographs of these trees from the past and present.

Japanese larch and Japanese arborvitae near Yumoto

In the photographs that Wilson made near Yumoto on October 16, 1914, we looked at the probable view from Lake Karikomi, which takes an hour to reach by walking from Yumoto, and concluded that he must have traveled along a footpath that had been drawn from Yumoto to the lake in an old Japanese topographical map, published in 1915. While walking along the footpath, we immediately encountered an inspirational sight. The massive trunk of a Japanese larch (*Larix kaempferi*) that we had previously seen was standing in plain view. This tree was the one from Wilson's 1914 photograph, which appeared as plate XVI in his book *The Conifers and Taxads of Japan,* published in 1916. Information from the label on the back of the photo mount indicated that the tree's trunk was 12 feet (366 centimeters) in girth when originally photographed. In 2008, the tree was 12.5 feet (382 centimeters) in girth and 95 feet (29 meters) in height, demonstrating slight growth. Nikko is famous for its native larch, and this tree is a fine representative of the larch in this region.

In Wilson's larch photo, a tree with multiple trunks can be seen just behind the man posing next to the larch. This tree is a Japanese arborvitae (*Thuja standishii*), photos of which also appear in his book (plates LII and LIII). It is surprising that a branch that inclined left and downward, as well as the spatial form of the tree behind the Japanese arborvitae, were in precisely the same positions as they were a hundred years ago (AEE-03655 and view in 2008). Now the tree is 15.9 feet (484 centimeters) in girth and 76 feet (23 meters) in height, while in 1914 it was 11 feet (335 centimeters) in girth and 45 feet (14 meters) in height.

After an hour of walking, we reached the lakeside of Lake Karikomi. We tried to locate a massive Japanese bird cherry (*Prunus ssiori*), with a girth of 9 feet (274 cm) in 1914, that had stood at the water's edge. Although we were able to track down the view from behind the tree, the tree is no longer in existence.



Japanese bird cherry (*Prunus ssiori*) near Yumoto, Nikko, on October 16, 1914, photographed by E. H. Wilson (AEE-03646 from the Arnold Arboretum Archives).

M. AIZAWA

Photograph from the same position as that of the photograph above at Lake Karikomi on December 21, 2008.

Japanese yews and another Japanese arborvitae around Lake Chuzenji

Next, we examined the trees around Lake Chuzenji, which is located at the foot of Mount Nantai, a volcano that rises to a height of 8,156 feet (2,486 meters). Because the embassy villas of several countries were located around the lake during the Meiji era, foreign visitors may be familiar with this area.

The Nikko Futarasan-Jinja Chugushi Shrine is located on the north side of Lake Chuzenji. Jack and Wilson both visited this shrine.

Jack photographed two tall trees (AEE-00175 and 00176) in this shrine. The two tall trees are now lost. According to the information from the label of Jack's photo, these trees were Japanese umbrella pine (*Sciadopitys verticillata*). However, we wonder if these trees may have been Japanese soft pine, *Pinus parviflora* var. *pentaphylla,* considering their shapes and the non-native status of *Sciadopitys verticillata* in Tochigi. There is the possibility, though, that *Sciadopitys verticillata* was purposely planted at the shrine, as is occasionally observed in east and west Japan. In these photos (AEE-00175 and 00176), gravel sediment can be seen on the ground, which represents the remains of a massive landslide on Mount Nantai caused by a typhoon in September 1902. The shrine buildings and two tall trees in front of the building barely escaped the damage.

In the photo AEE-00175, a Japanese yew (*Taxus cuspidata*) can be seen located to the right of the two tall trees. This tree is still alive and it is now designated as a natural monument of Tochigi Prefecture. The age of the tree, as estimated from the age of a broken large branch, is more than 1,000 years. The tree was last measured at 12.8 feet (390 centimeters) in girth and 62.3 feet (19 meters) in height in a 1988 investigation by the Ministry of Environment of Japan.

Another massive Japanese yew photographed by Jack (AEE-00180) is still alive behind a main building of the shrine. Jack indicated that this tree was more than 3.5 feet (107 centimeters) in diameter and 50 feet (15 meters) in height in 1905. In 2015, the tree was 3.9 feet (119 centimeters) in diameter and 68.9 feet (21 meters) in height. When we observed the tree in 2010, its trunk was covered with a plastic net for protection against bark stripping by sika deer; in Nikko and throughout Japan, bark stripping by sika deer is now among the most serious problems facing forest ecosystem and forestry. Japanese yew is one of the favorite plants of sika deer.

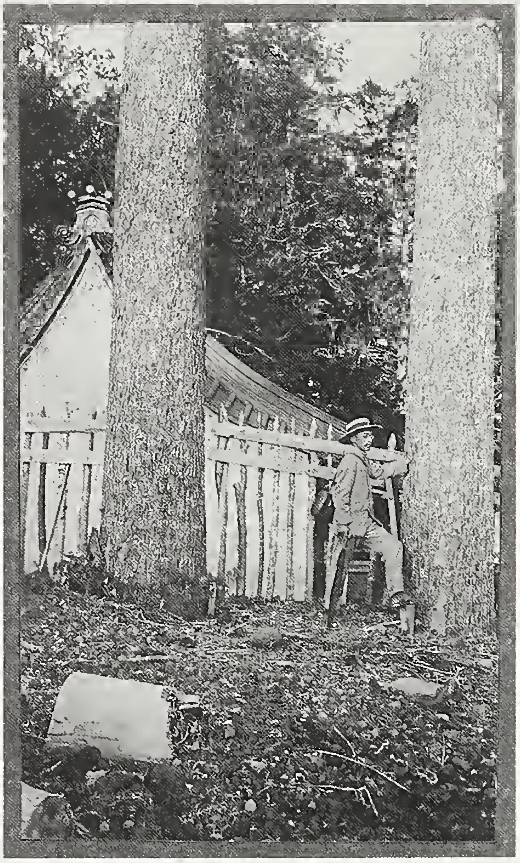
The Tachiki-Kannon temple is located on the east side of Lake Chuzenji. A wooden standing statue of the eleven-faced, one-thousand-armed Kannon Bosatsu is enshrined in the main hall of the temple. This Kannon Bosatsu was carved into a standing tree with roots ("Tachiki" in Japanese), which is why the temple is called "Tachiki-Kannon." This Kannon was said to be carved in

A torii (gateway) at the entrance of Nikko Futarasan-Jinja Chugushi Shrine, located on the north side of Lake Chuzenji on May 27, 1914, photographed by E. H. Wilson (AEE-03430 from the Arnold Arboretum Archives).

M. AIZAWA

Photograph from the same position as that of the left photograph on November 4, 2015.

Japanese umbrella pine (*Sciadopitys verticillata*), Lake Chuzenji , on August 10, 1905, photographed by J. G. Jack (AEE-00175 from the Arnold Arboretum Archives); a Japanese yew (*Taxus cuspidata*) is located to the right of the two tall trees and Lake Chuzenji is seen behind the buildings.



Sciadopitys verticillata, Lake Chuzenji, on August 10, 1905, photographed by J. G. Jack (AEE-00176 from the Arnold Arboretum Archives).

M. AIZAWA

The shrine buildings, with a sacred *Taxus cuspidata* surrounded by a red wooden fence (seen lower right), at the Nikko Futarasan-Jinja Chugushi Shrine, Lake Chuzenji, on July 10, 2010.

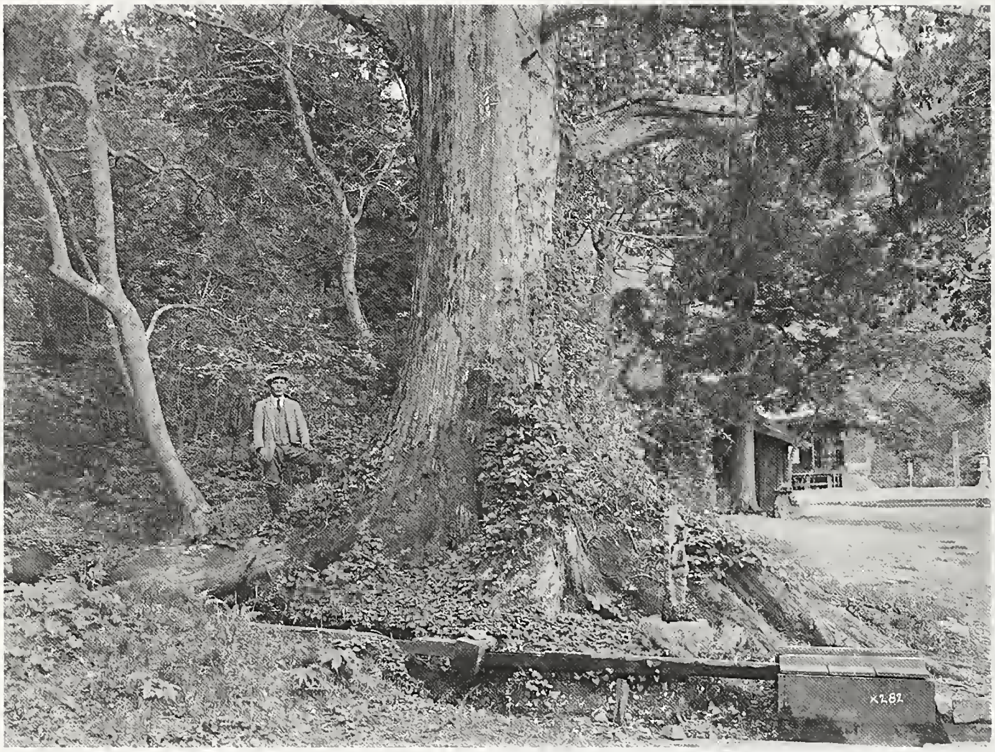
M. AIZAWA

A front view of the sacred *Taxus cuspidata* surrounded and protected by a red wooden fence at the Nikko Futarasan-Jinja Chugushi Shrine, Lake Chuzenji, on July 10, 2010.

Taxus cuspidata, Lake Chuzenji, on August 10, 1905, photographed by J. G. Jack (AEE-00180 from the Arnold Arboretum Archives).

M. AIZAWA

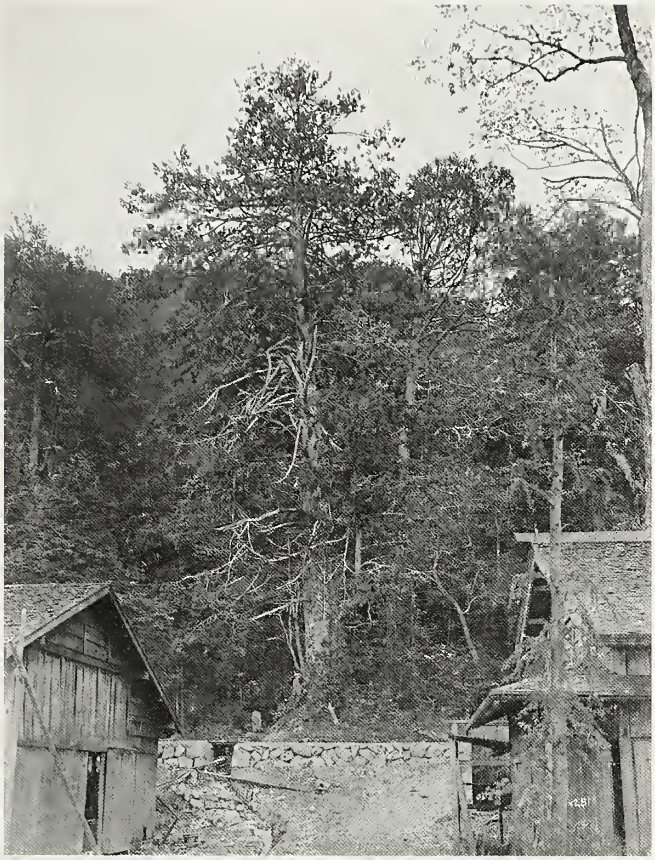
Probably the same *Taxus cuspidata* at the Nikko Futarasan-Jinja Chugushi Shrine, by Lake Chuzenji on November 4, 2015. Note the plastic mesh fencing to deter sika deer from stripping bark from the trunk.



"*Chamaecyparis obtusa*" near "Kwannon Temple," by Lake Chuzenji, on May 29, 1914, photographed by E. H. Wilson (AEE-03425 from the Arnold Arboretum Archives). The tree is actually Japanese arborvitae (*Thuja standishii*).

T. OHKUBO

The same *Thuja standishii* (not *Chamaecyparis obtusa*) at the Tachiki-Kannon temple, Lake Chuzenji, on March 1, 2007.



"*Chamaecyparis obtusa*," near "Kwannon Temple," Lake Chuzenji, on May 29, 1914, photographed by E. H. Wilson (AEE-03424 from the Arnold Arboretum Archives). The tree is actually Japanese arborvitae (*Thuja standishii*).

M. AIZAWA

Thuja standishii (not *Chamaecyparis obtusa*) at the Tachiki-Kannon temple, Lake Chuzenji on July 10, 2010.

the late eighth century. The temple was originally located next to the Nikko Futarasan-Jinja Chugushi Shrine on the north side of Lake Chuzenji. However, the temple was destroyed by the debris flow from the above-mentioned landslide in 1902 and the Kannon was swept away into the lake. The statue was subsequently beached, and the temple was reconstructed in its beached location in 1913.

The tree that stood out most conspicuously at the temple was another Japanese arborvitae that Wilson photographed on May 29, 1914 (AEE-03424, 03425). Wilson described this tree as a Hinoki cypress (*Chamaecyparis obtusa*), but it is actually a Japanese arborvitae. In 2010, the tree was 19.8 feet (603 centimeters) in girth and 103 feet (32 meters) in height, indicating slight growth from the 19 feet (579 centimeters) in girth and 90 feet (27 meters) in height observed in 1914. According to the giant tree database of Japan, only a few Japanese arborvitaes in the country have girths greater than 32.8 feet (10 meters). The biggest specimen of the species in Tochigi Prefecture is reported to be 21.0 feet (640 centimeters) in girth, located in Yunishigawa, Nikko. The Japanese arborvitae that Wilson photographed must now be comparable to that recorded tree.

Wilson's trees at the shrines and temples of Nikko

A complex in Nikko consisting of two shrines (Nikko Toshogu Shrine and Futarasan Shrine) and one temple (Rinno-ji Temple) was designated as a UNESCO World Heritage Site in 1999.

The Nikko Toshogu Shrine is the mausoleum of Ieyasu Tokugawa, who was the first Grand General and established a central government in Edo (present-day Tokyo) with 15 of his descendants that lasted roughly 260 years (Edo era, 1603–1867). We tracked down the viewpoint of Wilson's photo (AEE-03753) at the front of the five-story pagoda at the shrine, together with the Japanese cedar (*Cryptomeria japonica*) trees to the left of the pagoda and the Hinoki cypress trees to the right. The trees seem to have grown over the century between the two photographs.

Another photograph (AEE-03754) was taken at the front approach of Taiyuin Reibyo, the mausoleum of Iemitsu Tokugawa, who was the third Grand General, in the Rinno-ji Temple near the Toshogu Shrine. A massive Japanese cedar tree is now present to the side of the approach to the Nioo gate (the tile-roofed red wooden gate in the lower left of the right photograph, p. 29).

Five-story pagoda with trees on May 13, 1914, photographed by E. H. Wilson (AEE-03753 from the Arnold Arboretum Archives).

T. OHKUBO

Photograph from the same position as that of the left photograph on January 13, 2007.

Japanese cedar (*Cryptomeria japonica*), Nikko, on May 19, 1914, photographed by E. H. Wilson (AEE-03754 from the Arnold Arboretum Archives).

T. OHKUBO

Photograph from the same position as that of the left photograph on January 13, 2007.

Forests after the fires of the 1890s near Yumoto

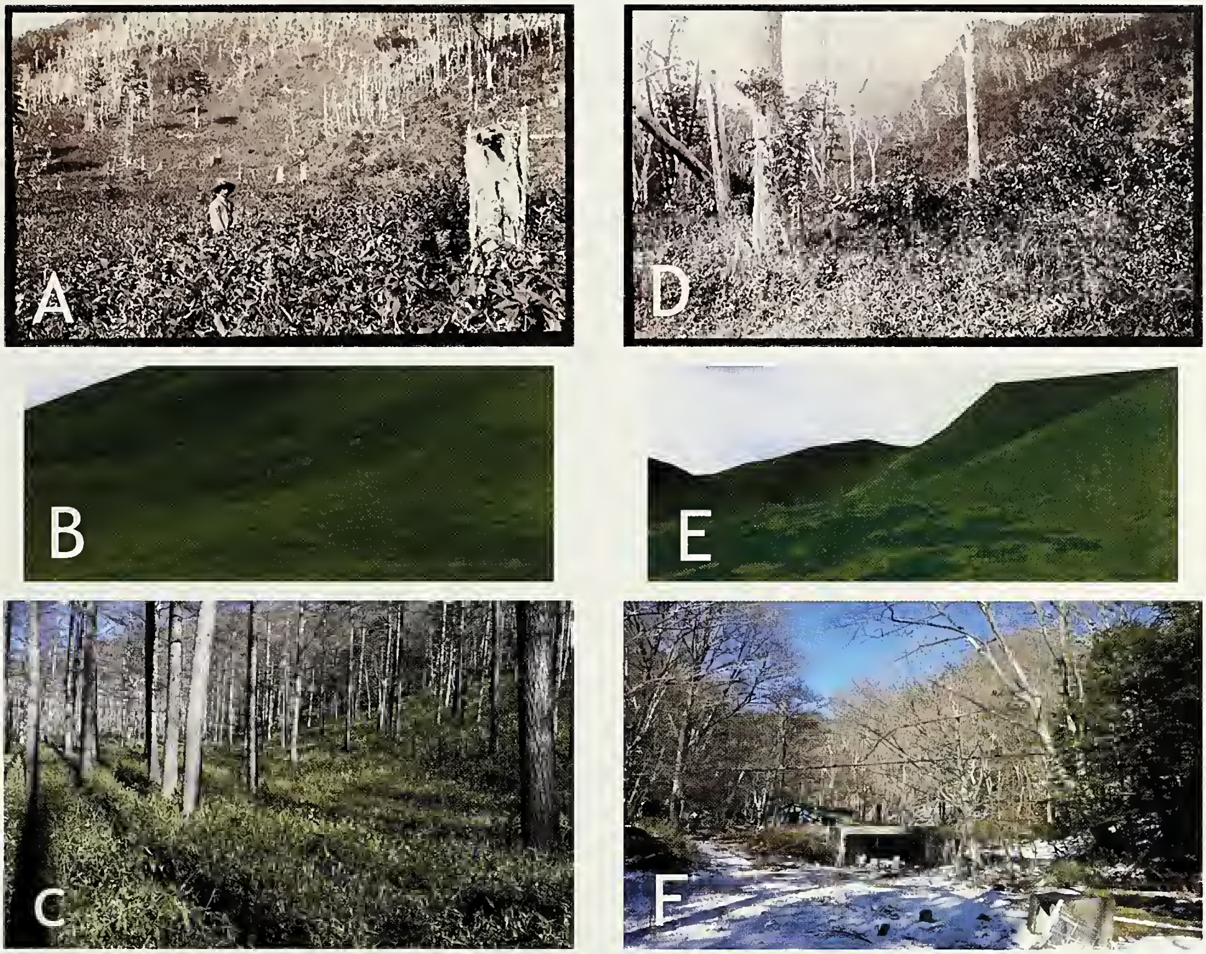
Finally, we introduce our recent study (Ishida et al. 2013), which provided evidence for forest fires near Yumoto in the Meiji era and was inspired by Jack's photographs.

Jack photographed in Yumoto two views of forests after fires, entitled "Japan-Forestry" (AEE-00202 and 00203). According to the information from the labels, forest fires after lumber harvest had occurred on the south slopes, which were originally covered with fir (*Abies*), hemlock (*Tsuga*), larch (*Larix*), birch (*Betula*), oak (*Quercus*), and other trees, and had burned from May 15 to June 15 around 1893. Locating these burned forests bolsters the understanding of the forest dynamics for the century after a fire. Using Jack's photographs, we tried to locate the sites when the deciduous species were leafless, giving us a better view of the skyline and geological features, but we did not identify the locations in a year of searching.

But then, when we looked at an old Japanese topographical map drawn in 1915, we noticed that it indicated the presence

of *Sasa* (dwarf bamboo) grasslands with standing dead or burned trees around Yumoto. Therefore, we supposed the *Sasa* grasslands would have resulted from forest fires. With this insight, we again attempted to locate the viewpoints of Jack's photos in the *Sasa* grasslands using a 3-D topographical map. At last, we were able to track down these locations. One area is now an 84-year-old plantation of Japanese larch mixed with birch (*Betula ermanii*). Another location is presently deciduous forest dominated by oak (*Quercus mongolica* var. *grosseserrata*). In addition, our literature survey of forest fires, investigation of tree age structure, and charcoal particle analysis for the soil surface demonstrated that forest fires had surely occurred at the photograph locations. The mountainous regions of Nikko contain picturesque forests consisting of birch or oak. Our study implied that these forests likely resulted from succession growth after the fires.

E. H. Wilson photographed this view of Yumoto (village) and the surrounding area in the Nikko region on October 19, 1914. He noted the presence of Japanese larch (*Larix kaempferi*) and Nikko fir (*Abies homolepis*) in the forest visible in the foreground. (AAE-03656 from the Arnold Arboretum Archives.)



ISHIDA ET AL. 2013

A (AEE-00202) and D (AEE-00203), views of previously burned forest on slopes in Yumoto photographed on August 11, 1905, by J. G. Jack; B and E, birds-eye views of the slopes constructed using Kashmir 3-D software; C and F, current views of the slopes with maturing forests on December 1 and December 4, 2010.

Acknowledgements

We are grateful to the people who helped us locate these trees in Nikko, and we also thank R. Primack for encouraging us to locate the Japanese trees of the Arnold Arboretum archives. The works of Primack and Ohkubo (2008) and Flanagan and Kirkham (2009) inspired us to write this article.

References

Flanagan, M. and T. Kirkham. 2009. *Wilson's China: A century on.* Richmond, Surrey: Kew Publishing, Royal Botanic Gardens, Kew.

Ishida, Y., M. Aizawa, and T. Ohkubo. 2013. Evidence of forest fires in the Meiji era in the mountainous region of Nikko on the basis of charcoal particle analysis. *Japanese Journal of Forest Environment* 55: 1–8. (in Japanese with English summary)

Primack, R. and T. Ohkubo. 2008. Ancient and notable trees of Japan: then and now. *Arnoldia* 65 (3): 10–21.

Mineaki Aizawa and Tatsuhiro Ohkubo are Professors in the Department of Forest Science, Utsunomiya University, Utsunomiya, Tochigi, Japan.

Woodland Restoration: 30 Years Later

Lauren Mandel and Emily McCoy

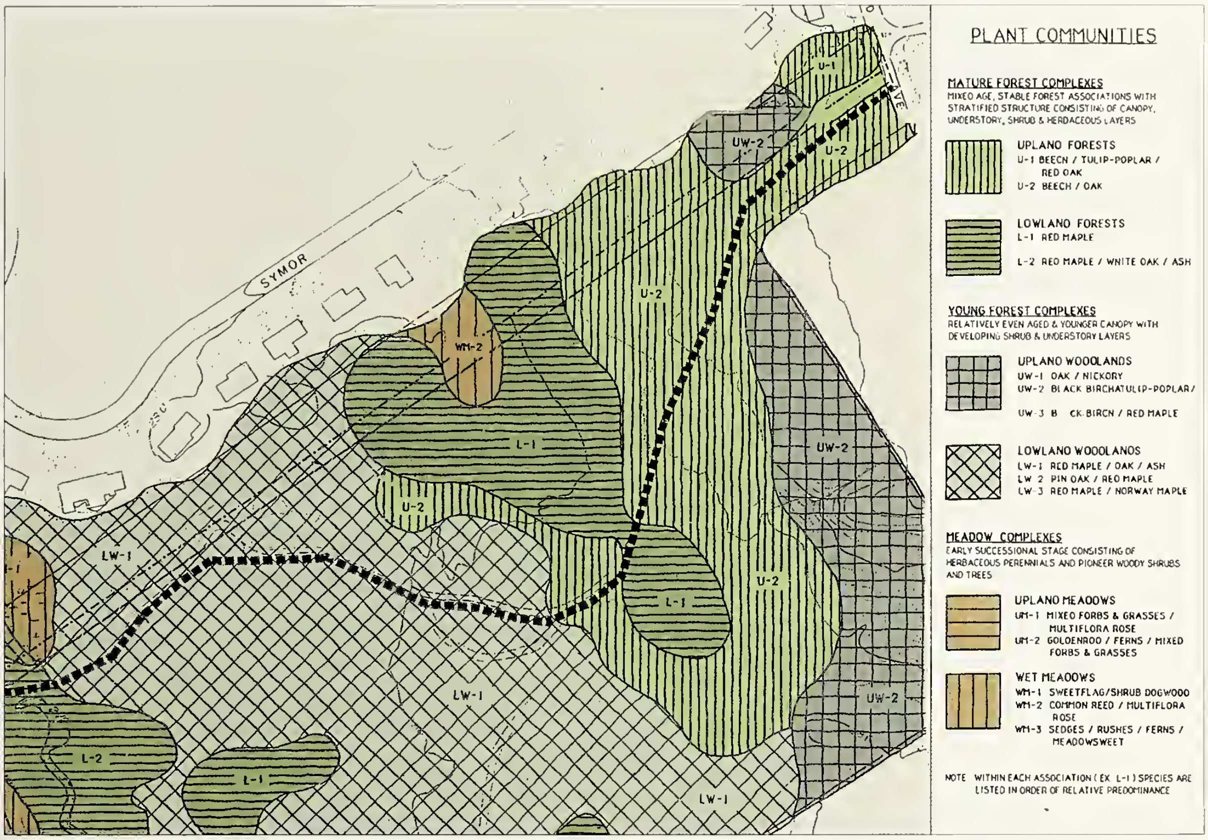
Walking along the wooded trails in Loantaka Brook Reservation, Morristown, New Jersey, it's hard to believe that a 36-inch-diameter natural gas pipeline lies underfoot. The mature oak-beech forest overhead and native herbaceous understory don't suggest that this was a construction zone, nor do the runners or cyclists zipping by appear to notice.

The Algonquin Gas Transmission pipeline, which transports 2.74 billion cubic feet of natural gas per day between New Jersey, New York, and parts of New England (Spectra Energy 2015), runs directly through the reservation. Its installation through the wooded landscape began 30 years ago, in 1986. Continual site monitoring suggests that the use of minimally invasive construction methods during the pipeline's installation, paired with innovative habitat restoration techniques and stewardship guidelines, have resulted in the long-term ecological success of this sensitive, post-construction landscape.

THE SITE

The reservation, which is used primarily for walking, running, cycling, horseback riding, and cross-country skiing, lies 25 miles due west of Manhattan, within the northernmost portion of New Jersey's Great Swamp watershed. The

Loantaka Brook Reservation, Morristown, New Jersey, contains diverse plant communities including several forest and meadow types. To limit ecological disruption, a natural gas pipeline installed through the reservation in 1986 was carefully routed and constructed. Here, the pipeline alignment is being marked.



As part of the preparation for the pipeline installation in 1986, a plant community inventory that mapped the various meadow, woodland, and forest species assemblages was completed. (Color coding added for this article.)

Loantaka Brook, the reservation's namesake, flows from just north of the reservation down into the neighboring Great Swamp National Wildlife Refuge, where it joins other flows that discharge into the Passaic River. The reservation falls within the Glaciated Reading Prong/Hudson Highlands regional ecosystem, with local soils containing glacial lake bottom deposits of fine sand and silt with clay.

Traversing this region, the 1,129-mile-long Algonquin pipeline connects to the mammoth Texas Eastern Transmission pipeline, which together provide approximately one-third of the continental United States with natural gas transportation infrastructure: The pipeline route was originally slated to run near a residential neighborhood in Morristown, but instead the Federal Energy Regulatory Commission mandated that the infrastructure be rerouted through the 744-acre reservation.

The reservation contains diverse plant communities that respond to the site's topography and land use history. In the 1980s, young forest dominated the reservation, with sizeable lowland woodland areas, primarily consisting of red maple (*Acer rubrum*), oak (*Quercus* spp.), and ash (*Fraxinus* spp.), all of a similar age. Upland woodlands were also present, with dominant oak, hickory (*Carya* spp.), black birch (*Betula lenta*), tulip poplar (*Liriodendron tulipifera*), and red maple species. Mature forest stands within the reservation consisted of mixed-age, stable plant associations with a stratified forest structure. Upland forest communities contained large populations of American beech (*Fagus grandifolia*), tulip poplar, and red oak (*Q. rubra*), while lowland forests were dominated by red maple, white oak (*Q. alba*), and ash. The site also contained meadows that, in the 1980s, were in an early successional state that exhibited herbaceous perennials, pioneer woody shrubs, and young trees. Upland meadow areas were dominated by forbs, grasses, multiflora rose, goldenrod, and ferns, while wet meadow

areas contained assemblages of grasses, shrub dogwood, common reed, multiflora rose, sedges, rushes, ferns, and meadowsweet.

Most of the pipeline runs through the reservation's red maple-oak-ash lowland woodland and through the beech-oak upland forest. The pipeline corridor intersects with other plant communities to a lesser degree, and it traverses underneath the Loantaka Brook and several of its tributary flows.

Pipeline installation typically disturbs and compacts a 75- to 100-foot-wide construction zone through the deployment of heavy machinery and straight-path clearcutting. Once the site is cleared, the topsoil is stripped and stockpiled, a trench is dug, the pipeline is laid and buried, the topsoil is replaced, and then the corridor is kept devoid of woody plants. This type of soil disturbance often leads to colonization by invasive species that then migrate, unimpeded, along the pipeline corridor. The quality of the reservation's woodlands and mature forest, however, stimulated an innovative joint approach to pipeline installation and woodland restoration, propelled by ecologically-driven design.

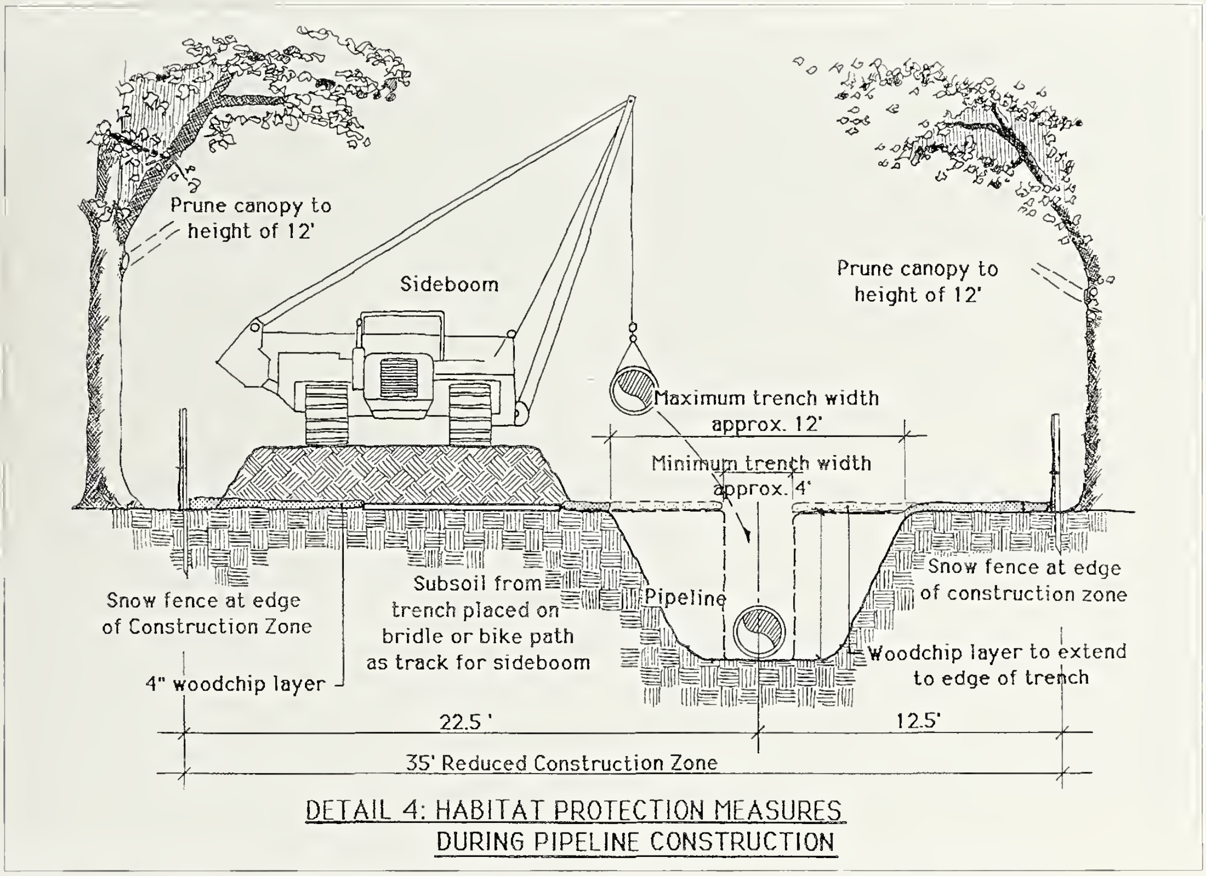
Using a crane with a side-boom, which could hoist from the side instead of the front, meant that the heavy equipment could install pipe in a tighter area without three-point turns, thus limiting the disruption zone.

CONSTRUCTION METHODS

The project was led by designers Leslie Sauer and Carol Franklin of Andropogon Associates, a Philadelphia-based landscape architecture and ecological planning firm. The project focused on four critical design and restoration elements: (1) realigning the pipeline route to target previously affected areas within the reservation; (2) limiting the construction zone width to 35 feet on average; (3) minimizing habitat disturbance during construction; and (4) conserving soil structure and plant communities by leaving the topsoil in place within the construction zone and removing and then reinstalling thick blocks of the upper soil layers and vegetation above the trench.

Initially, the Algonquin Gas Transmission Company (the pipeline's original owner) proposed a straight pipeline alignment that intersected sensitive habitat and several waterways within the reservation. In an effort to minimize disturbance, the landscape architect opted to realign the pipeline beneath the existing multi-use and bridle path system by connecting a series of short, linear pipe segments to conform to the meandering paths' geometry. To further limit the construction zone's impact, disturbance was limited to 35 feet on average, much less than the typical 75- to 100-foot pipeline corridors. Intentional variations in corridor width—from 50 feet in areas of natural opening, like fields, to 25 feet in special situations—responded to the reservation's naturally varying ecological conditions. This variation also created a more natural look, as opposed to the straight clear-cut that typifies pipeline installations. Within the construction zone, the pipeline trench itself was minimized to an unprecedented 4- to 12-foot width range, which limited deep soil disturbance to a narrow band. Downhill of wet meadow areas, a bentonite clay liner held moisture out of the trench and in the meadow, thereby maintaining the ecosystem's hydrology.

Construction equipment was carefully selected to further protect the site. Use of a crane with the ability to side-boom—meaning hoist to the side rather than the front—allowed access to the pipe's construction trench without needing extra space for multi-point turns. This type of crane is commonly deployed in other tight, linear construction sites such as those typical of railroad installation, and a small boom was selected for this project. Traffic by heavy machinery can wreak havoc on soil structure by



This figure shows details of habitat protection measures instituted during the 1986 pipeline installation.

compressing the soil's air-filled pores (Schäffer et al. 2007), and the pipe-laying machinery at the reservation weighed 90,000 pounds. To avoid extraneous soil compaction, the heavy machinery travelled along the existing multi-use and bridle paths whenever possible. Along the pipe-laying trench, the equipment drove over a 4-inch-thick woodchip layer topped with roughly 14 inches of excavated subsoil from the trench itself. This extra padding protected the underlying soil and tree roots from direct contact with the machinery. Under the padding was a fiber mat that was lifted after construction to pour the padding back into the trench.

The landscape architect additionally prioritized minimizing habitat disturbance. Construction fencing installed around the construction zone and staging areas (for construction material and equipment storage) kept machinery and people within designated zones. This continuous 4-foot-high, bright orange plastic fencing was installed without gaps or other potential entry points. Low silt fencing helped prevent fines from washing into the reservation's waterways, and flume pipes were used where necessary to maintain the Loantaka Brook's flow and avoid disrupting local aquatic organisms.

Careful tree removal and tree care further mitigated habitat disturbance during construction. Trees within the construction zone were carefully felled, lowered to the ground with ropes, and then removed or chipped for on-site use. When possible, some trees were only cut down to the ground-level (known as coppicing) in order to promote regeneration through sprouting after construction. Trees outside the construction zone that extended into the corridor were limbed up by an arborist, rather than being removed, to provide a 12-foot vertical clearance for machinery. Some affected trees received special aftercare, for example, all limbed beech trees received fertilization during the fall following construction and watering in the case of drought.

One of the most innovative construction methods deployed during the pipeline instal-


To preserve existing native plants and seedbanks, soil blocks were carefully lifted in advance of the construction trench, then relaid at the back of the line where the trench had been refilled. Seen here, soil blocks from the wet meadow are moved and temporarily stored (left), and later transplanted (right).

lation involved the skimming and transplanting of thick, vegetated soil blocks within the woodland, forest, and wet meadow portions of the corridor. Each day, a large piece of machinery fitted with a modified flat backhoe blade or "pie lifter" scraped soil blocks from the ground at the active trench's "front of the line." To prevent desiccation, the blocks were installed at the "back of the line" by the end of the day they were harvested, atop the day's freshly buried trench segment. Using this conveyor-belt-like method, it's estimated that, while some plant death was inevitable, no more than 20 percent of the blocks were rendered unusable.

Finally, upon completion of the pipeline installation, new asphalt multi-use paths and woodchip bridle paths were installed where needed.

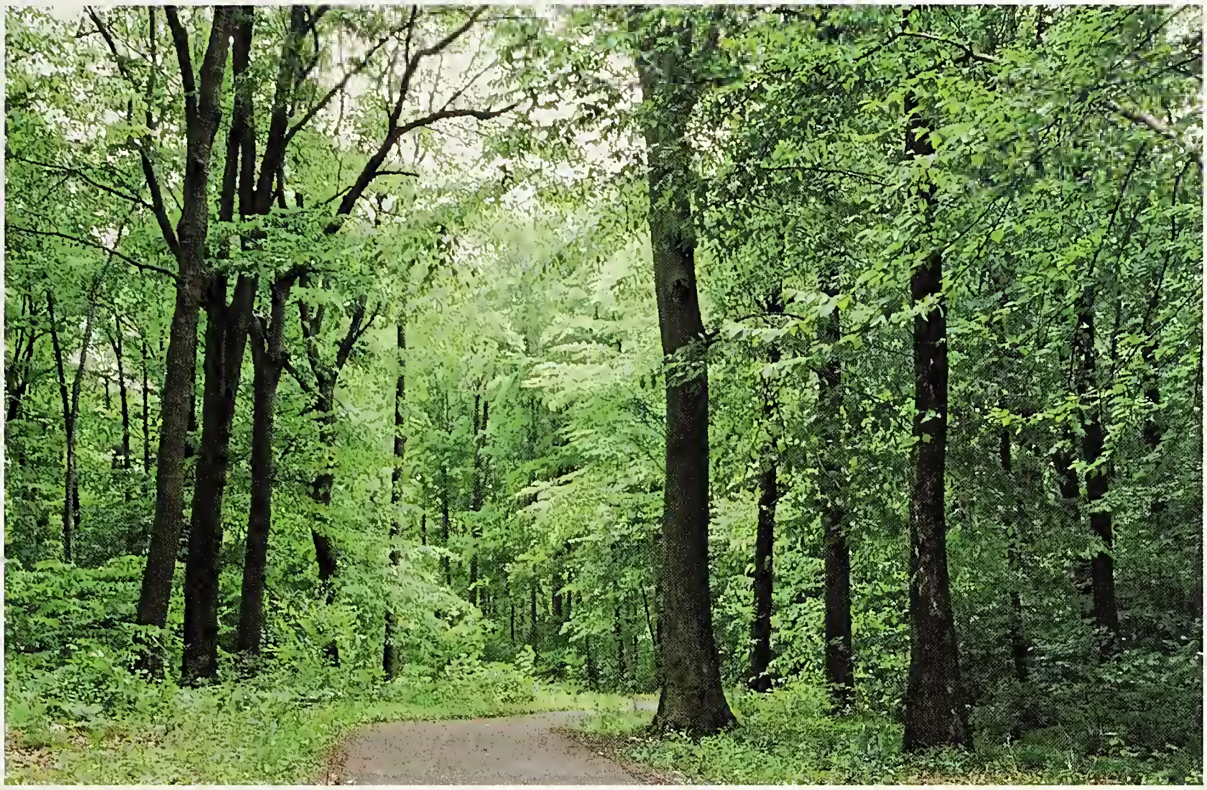
HABITAT RESTORATION

Luckily, the project's careful construction methods and use of vegetated soil blocks left minimal need for habitat restoration. Remaining meadow areas were restored through seeding and mulching with salt marsh hay. Affected stream banks were graded and then seeded immediately to minimize soil runoff into the waterways.

Woodland and forested areas required even less restoration. Most revegetation sprouted from the intact seedbank within the vegetated soil blocks. New woody and herbaceous growth within the construction zone matched the pre-construction species composition, albeit weighted slightly toward species that prefer more light. Young whips (unbranched tree seedlings) were planted to decrease this sunlight penetration and replace felled trees, since small whips generally grow quickly and were more economical than larger container-grown or balled-and-burlapped stock. While the new corridor openings resembled forest glades, the landscape architect believed that reestablishing a closed canopy overhead as quickly as possible would help minimize pressure from invasive plant species and the deleterious effects of fragmentation, two effects that plague traditional pipeline corridors.

MAINTENANCE

Once the meadow and woodland restoration areas were established, maintenance became a powerful tool in guiding the site's long-term ecological health. Along the paths, a 15-foot-wide right-of-way corridor was mown once every other year to prevent woody plants from establishing, as was required for emergency and pipeline maintenance vehicle access. Since invasive species often sprout at the edge of clearings, the Morris County Park Commission performed periodic herbicide-free invasive species removal within the pipeline corridor. Within the woodlands and forests, trees were permitted to sprout and mature in the remainder of the



One year after pipeline installation, the forest construction zone looked remarkably undisturbed.

35-foot-wide construction zone, while invasive species were eliminated. Approximately 25 feet of wooded area beyond the construction zone, in both directions, was considered a Park Commission zone of special management.

MONITORING METHODS

Various types of landscape monitoring occurred immediately before the pipeline's 1986 construction, periodically from the late 1980s through the late 2000s, and then with more rigor in 2013. Landscape architect Leslie Sauer recalls that in the 1980s landscape performance monitoring was not common practice and, because of this "analysis paralysis," the pipeline owner did not agree to allocate funds for a formal investigatory effort (Sauer 2015). Informal monitoring was therefore deployed initially to inform the designers of the effectiveness of the new design, construction, and stewardship strategies.

The site investigations performed in 1986, in preparation of the pipeline installation, included a plant community inventory that mapped the various meadow, woodland, and forest species assemblages. Additionally, a tree inventory and shrub valuation within and adjacent to the realigned pipeline corridor helped designate each woody plant for protection or removal. One year after construction, the landscape architect visually monitored the site. For nearly three decades to follow, monitoring methods consisted primarily of observation and photographic analysis during periodic site visits.

In order to assess the ecological success of the implementation strategies after nearly 30 years, the integrative research department at Andropogon Associates performed vegetation and soil sampling in June 2013. The assessments aimed at understanding how the pipeline construction methods affected the biodiversity and soil health of the forest within the construction zone in comparison to areas left undisturbed during construction. The researchers randomly selected study areas within and outside of the pipeline corridor and then conducted a comparative analysis of species diversity. To calculate the site's species diversity the Shannon

index (a statistical formula that assumes the species within the test plots reflect the full biodiversity throughout the site) was used, then the Simpson index equation, which is used to determine the relative dominance of each species, was applied. Additionally, the degree of soil compaction within the study areas was determined using a cone penetrometer. In the face of financial constraints, three study areas within the construction zone and three areas outside the construction zone were chosen for more in-depth analyses that included species identification and quantification. Each study area consisted of a 20-square-foot quadrat (a randomly selected plot of a standard size, used for species sampling). Ten additional quadrats and two transects were assessed inside and outside of the construction zone by visually evaluating the proportion of individual species within each zone and by measuring soil compaction with the penetrometer. Complete species counts were not performed in these areas.

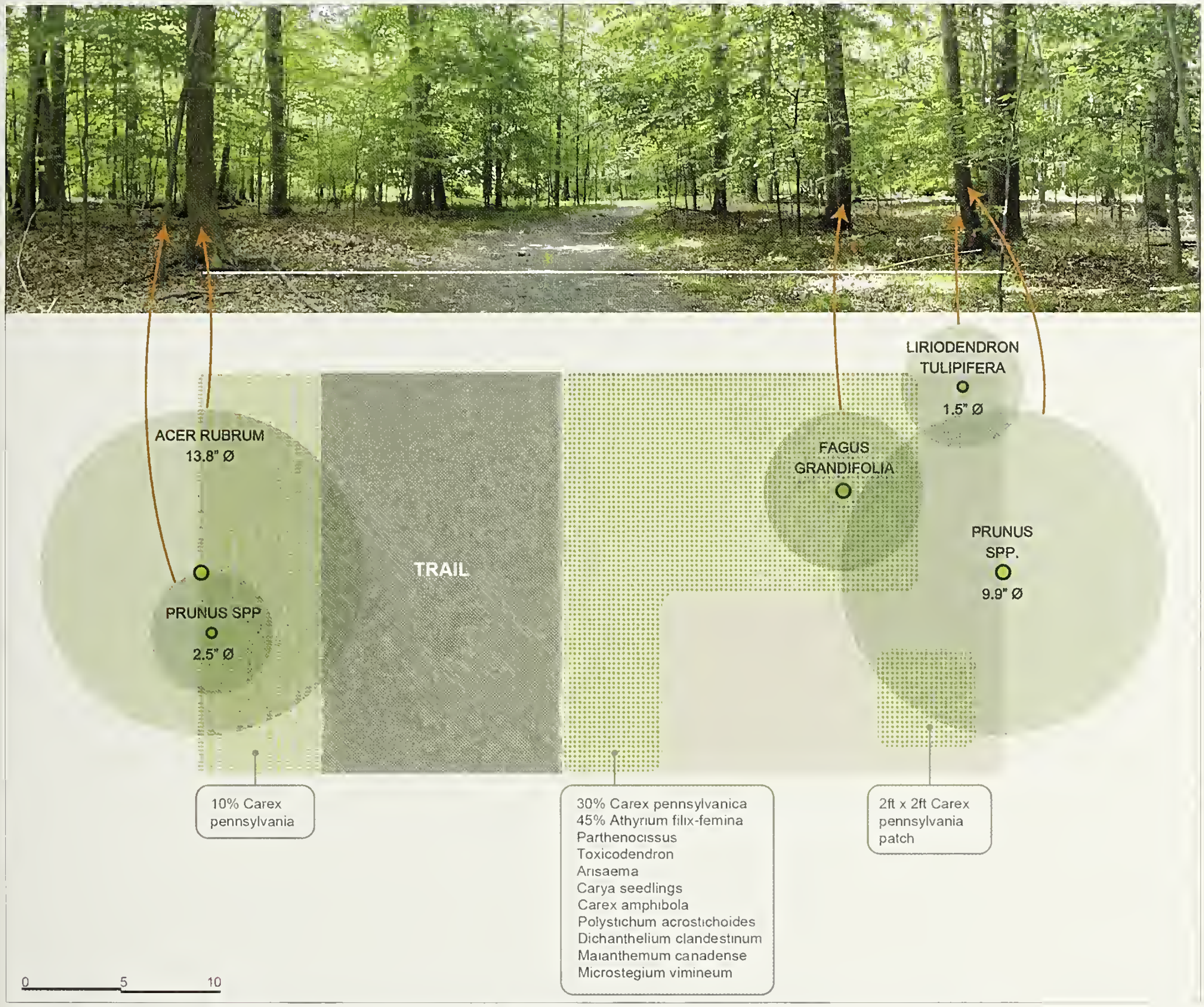
FINDINGS

One year after construction dense stands of ferns, wildflowers, and re-sprouting trees and shrubs were observed (Storm et al. 2009). A small increase in the number of plant species was noted, presumably the result of increased light levels in areas within the site where trees were removed or thinned. Succession (the progressive replacement of one plant community with another), however, was not observed, most likely because revegetation resulted from ger-

TREE VALUATION CHART #1
TREES (>6" D.B.H.) REMOVED FOR CONSTRUCTION

	Species	D.B.H.	Stem Area	Base Value (in dollars)	Species rating	Condition rating	Location rating	Tree Value (in dollars)
1	Acer rubrum	6	28.3	940	0.8	0.9	0.6	406.08
2	Ulmus rubra	#12	#VALUE	2980	0.6	0.8	0.6	858.24
3	Ulmus rubra	#6	#VALUE	940	0.6	0.8	0.6	270.72
4	Acer rubrum	18	254	5595.48	0.8	1	0.6	2685.8304
5	Acer rubrum	#12	#VALUE	2980	0.8	0.9	0.6	1287.36
6	Quercus palustris	16	201	4421.12	0.8	0.9	0.6	1909.9238
7	Acer rubrum	#12	#VALUE	2980	0.8	0.8	0.6	1144.32
8	Acer rubrum	#12	#VALUE	2980	0.8	0.9	0.6	1287.36
9	Acer rubrum	16	201	4421.12	0.8	0.9	0.6	1909.9238
10	Ulmus rubra	#6	#VALUE	940	0.6	0.8	0.6	270.72
11	Ulmus rubra	#8	#VALUE	1510	0.6	0.8	0.6	434.88
12	Quercus palustris	24	452	9947.52	0.8	0.9	0.6	4297.3286
13	Acer rubrum	#12	#VALUE	2980	0.8	0.9	0.6	1287.36
14	Quercus palustris	24	452	9947.52	0.8	0.9	0.6	4297.3286
15	Acer rubrum	#8	#VALUE	1510	0.8	0.9	0.6	652.32

As part of the planning process before pipeline installation in 1986, the total monetary value of the trees to be removed and protected within the pipeline construction site was assessed (part of the valuation chart is seen here). The valuation method was established by the International Society of Arboriculture in their Guide for Establishing Values of Trees and Other Plants (Sixth Edition, 1983). For each tree the following is listed: species; D.B.H. (diameter at breast height) in inches; stem area at breast height, in square inches (most trees below 12" D.B.H. were assigned "#value," meaning the commercial nursery stock replacement cost); base value ($22 per square inch of stem area); percentage ratings for species, condition, and location derived from the ISA Guide; and a total tree valuation in dollars.



A study in 2013 assessed plant species in several areas, including this transect across the construction zone.

mination within the existing seed bank rather than the introduction of new pioneer species. More importantly, perhaps, was the realization that the seed bank remained viable within the soil blocks that were lifted and reset, and that this habitat restoration method successfully maintained the pre-construction forest, woodland, and wet meadow species profiles while keeping new species at bay.

Thirty years later, comparative measurements and observation revealed that the native understory plant communities present in 2013 closely matched the pipeline corridor's pre-construction species. These included mixed-age American beech and understory species like striped prince's pine (*Chimaphila maculata*), Jack-in-the-pulpit (*Arisaema triphyllum*), and lady fern (*Athyrium filix-femina*) (McCoy 2013). This healthy species composition reveals a stark contrast to the nearby Texas Eastern Transmission pipeline, which was constructed around the same time as the Algonquin Gas Transmission pipeline using traditional construction methods. In 2013, the Texas Eastern Transmission pipeline's 100-foot-wide, linear disturbance zone exhibited low species diversity dominated by orchard grass (*Dactylis glomerata*) and other non-native plants.

In one of the project's woodland construction zones native plants including wildflowers, ferns, and sedges can be seen one year after pipeline installation.

In the 2013 study, biodiversity and soil compaction levels were found to be better or very similar in the Algonquin Gas Transmission pipeline corridor compared to adjacent areas outside of the disturbance zone, in almost all instances. Despite these similarities in biodiversity and soil compaction, individual plant sizes, and thus biomass, were less in the construction zone, as one might assume. Additionally, in unpaved areas native species regeneration was observed directly atop the pipeline with only limited patches of one invasive species, Japanese stiltgrass (*Microstegium vimineum*).

BIG PICTURE

Natural gas pipeline alignment and construction is just as controversial today as it was in the 1980s, particularly in light of the recent Marcellus Shale boom. Review of several opposing resolutions and petitions in response to recent pipeline projects reveals that many of these recent projects are routed as close as 50 feet from residences and through significant landscapes that provide abundant ecosystem services (Township of Chesterfield 2015). This issue is significant, since gas pipelines within the United States now cover more than 2.49 million miles (Township of Chesterfield 2015) and several facets of their construction standards, such as corridor width and revegetation techniques, have remained stagnant or become increasingly environmentally harmful. For example, the Interstate Natural Gas Association of America, a trade organization for the natural gas transmission pipeline industry, now recommends a 95- to 110-foot-wide construction zone for a 30- to 36-inch-diameter gas pipeline (Interstate Natural Gas Association of America 2013).

Natural gas (distribution, gathering, and transmission), hazardous liquid, and liquefied natural gas operation and transmission activi-

COURTESY OF ROBERT VOLKMAN, JEDROC CONSULTING SERVICES

Typical pipeline construction involves clearcutting and environmental disruption of wide swaths of land. This photograph shows installation of a natural gas pipeline in northeastern British Columbia.

ties result in human injuries and fatalities as well as environmental damage from spilled hazardous liquids. From 1995 to 2014, 360 fatalities and 1,365 injuries have been associated with gas and hazardous liquid pipelines in the United States, and 2,171,575 spilled barrels of hazardous liquids have been reported to Pipeline and Hazardous Materials Safety Administration (Note that gas leaks are not quantified in PHMSA reports.) These environmental concerns are particularly heightened in residential neighborhoods and areas that serve as sources of drinking water.

The best way to prevent habitat degradation is, of course, to avoid disturbing sensitive landscapes in the first place. However, when disturbance is unavoidable, minimally-invasive construction techniques paired with ecologically sound restoration practices offer the best possible opportunity for affected ecosys-

tems to rebound and continue contributing to the larger system. The Loantaka Brook Reservation case study demonstrates how simple, cost effective techniques with minimal inputs can protect natural resources while accommodating infrastructure.

References

Andropogon Associates. 1986. Design criteria for site protection and park habitat restoration for a revised alignment of Algonquin Gas Transmission company's proposed natural gas pipeline through the Loantaka Brook Reservation of the Morris County Parks Commission Morris County, New Jersey. Philadelphia: Andropogon Associates.

Andropogon Associates. 2013. [Vegetation and soil sample data set]. Unpublished raw data.

Interstate Natural Gas Association of America. 2013. Building interstate natural gas transmission pipelines: A primer. Retrieved 14 December 2015 from www.ingaa.org/file.aspx?id=19618

Miodovnik, Yaki. Personal correspondence. 16 December 2015.

Najafi, M.and K. O. Kim. 2004. Life-cycle-cost comparison of trenchless and conventional open-cut pipeline construction projects. In: *Proceedings of the ASCE Pipeline Division Specialty Congress-Pipeline Engineering and Construction.* San Diego, California. pp. 635–640.

Sauer, Leslie. 2014. *An overview of pipeline construction impacts with recommendations for reducing environmental damage.* Bristol, Pennsylvania: Delaware Riverkeeper Network.

Sauer, Leslie. Personal correspondence. 16 December 2015.

Sauer, Leslie. Personal correspondence. 18 December 2015.

Schäffer, B., M. Stauber, R. Müller, and R. Schulin. 2007. Changes in the macro pore structure of restored soil caused by compaction beneath heavy agricultural machinery: a morphometric study. *European Journal of Soil Science*, 58: 1062–1073.

Spectra Energy. 2015. Retrieved 14 December 2015 from www.spectraenergy.com/Operations/US-Natural-Gas-Pipelines/Algonquin-Gas-Transmission/

Strom, S., K. Nathan, J. Woland, and D. Lamm. 2009. *Site engineering for landscape architects.* Hoboken, New Jersey: John Wiley and Sons. pp. 206–209.

Summit Bechtel Reserve. 2010. How to make a new camp out of an old one. Retrieved from www.youtube.com/watch?v=lvn9JBB2UNc

Township of Chesterfield, New Jersey. 2015. Resolution opposing the installation of the Southern Reliability link natural gas pipeline along county route 528 through Chesterfield Township (Resolution No. 2015-4-2). Chesterfield County, New Jersey.

United States Federal Energy Regulatory Commission and Algonquin Gas Transmission. *FERC Application* (Docket No. CP14-96-000). Retrieved from www.ferc.gov/CalendarFiles/20150303170720-CP14-96-000.pdf

United States Federal Energy Regulatory Commission and Tennessee Gas Pipeline Company. 2011. Northeast upgrade project: Environmental assessment (Docket No. CP11-161-000). Retrieved from www.nj.gov/dep/greenacres/pdf/eas_for_neup_ferc_nov_11_2011.pdf

United States Federal Energy Regulatory Commission and Transcontinental Gas Pipe Line Company. *FERC Application* (Docket No. CP12-30-000). Retrieved from www.ferc.gov/EventCalendar/Files/20121102175650-CP12-30-000.pdf

United States DOT Pipeline and Hazardous Materials Safety Administration. 2007. Safe pipelines FAQ's. Retrieved 14 December 2015 from www.phmsa.dot.gov/portal/site/PHMSA/menuitem.6f23687cf7b00b0f22e4c6962d9c8789/?vgnextoid=2c6924cc45ea4110VgnVCM1000009ed07898RCRD&vgnextchannel=f7280665b91ac010VgnVCM1000008049a8c0RCRD&vgnextfmt=print

United States DOT Pipeline and Hazardous Materials Safety Administration. (n.d.) Retrieved 14 December 2015 from https://hip.phmsa.dot.gov/analyticsSOAP/saw.dll?Portalpages&NQUser=PDM_WEB_USER&NQPassword=Public_Web_User1&PortalPath=%2Fshared%2FPDM%20Public%20Website%2F_portal%2FSC%20Incident%20Trend&Page=Significant&Action=Navigate&col1=%22PHP%20-%20Geo%20Location%22.%22State%20Name%22&val1=%22%22

Lauren Mandel, ASLA, is a landscape designer and researcher at Andropogon Associates and author of *EAT UP | The Inside Scoop on Rooftop Agriculture* (New Society Publishers, 2013). She holds a Master of Landscape Architecture from the University of Pennsylvania and a B.A. in Environmental Science.

Emily McCoy, ASLA, PLA, is the director of Integrative Research at Andropogon Associates and a lecturer at North Carolina State University. Emily holds a Master of Landscape Architecture and a GIS Certificate from North Carolina State University and a B.S. in Ecology.

LONGSTALK HOLLY, *ILEX PEDUNCULOSA* 369-49-I. KYLE PORT

36673667 U.S. POSTAL SERVICE STATEMENT OF OWNERSHIP, MANAGEMENT, AND CIRCULATION (Required by 39 U.S.C. 3685)

1. Publication Title: *Arnoldia*. 2. Publication No: 0004–2633. 3. Filing Date: October 29, 2015. 4. Issue Frequency: Quarterly. 5. No. of Issues Published Annually: 4. 6. Annual Subscription Price: $20.00 domestic; $25.00 foreign. 7. Complete Mailing Address of Known Office of Publication: Arnold Arboretum, 125 Arborway, Boston, Suffolk County, MA 02130–3500. 8. Complete Mailing Address of Headquarters of General Business Office of Publisher: Arnold Arboretum, 125 Arborway, Boston, Suffolk County, MA 02130–3500. 9. Full Names and Complete Mailing Address of Publisher, Editor, and Managing Editor: Arnold Arboretum, 125 Arborway, Boston, Suffolk County, MA 02130–3500, publisher; Nancy Rose, Arnold Arboretum, 125 Arborway, Boston, MA 02130–3500, editor. 10. Owner: The Arnold Arboretum of Harvard University, 125 Arborway, Boston, Suffolk County, MA 02130–3500. 11. Known Bondholders, Mortgagees, and Other Security Holders Owning or Holding 1 Percent or More of Total Amount of Bonds, Mortgages, or Other Securities: none. 12. The purpose, function, and nonprofit status of this organization and the exempt status for federal income tax purposes have not changed during the preceding 12 months. 13. Publication Name: *Arnoldia*. 14. Issue Date for Circulation Data Below: August 7, 2013. 15. Extent and Nature of Circulation. a. Total No. Copies. Average No. Copies Each Issue During Preceding 12 Months: 2,050. Actual No. Copies of Single Issue Published Nearest to Filing Date: 2,100. b. Paid and/or Requested Circulation. (1) Paid/Requested Outside-County Mail Subscriptions. Average No. Copies Each Issue During Preceding 12 Months. Copies Each Issue During Preceding 12 Months: 1,253. No. Copies of Single Issue Published Nearest to Filing Date: 1,217. (2) Paid In-County Subscriptions. Average No. Copies Each Issue During Preceding 12 Months. Copies Each Issue During Preceding 12 Months: 388. No. Copies of Single Issue Published Nearest to Filing Date: 395. (3) Sales Through Dealers and Carriers, Street Vendors, and Counter Sales: none. (4) Other Classes Mailed Through the USPS: none. c. Total Paid and/or Requested Circulation. Average No. Copies Each Issue During Preceding 12 Months: 1,641. Actual No. Copies of Single Issue Published Nearest to Filing Date: 1,612. d. Free Distribution by Mail. Average No. Copies Each Issue During Preceding 12 Months: 43. Actual No. Copies of Single Issue Published Nearest to Filing Date: 45. e. Free Distribution Outside the Mail: Average No. Copies Each Issue During Preceding 12 Months: 300. Actual No. Copies of Single Issue Published Nearest to Filing Date: 300. f. Total Free Distribution: Average No. Copies Each Issue During Preceding 12 Months: 343. Actual No. Copies of Single Issue Published Nearest to Filing Date: 345. g. Total Distribution: Average No. Copies Each Issue During Preceding 12 Months: 1,984. Actual No. Copies of Single Issue Published Nearest to Filing Date: 1,957. h. Copies Not Distributed. Average No. Copies Each Issue During Preceding 12 Months: 66. Actual No. Copies of Single Issue Published Nearest to Filing Date: 143. i. Total. Average No. Copies Each Issue During Preceding 12 Months: 2,050. Actual No. Copies of Single Issue Published Nearest to Filing Date: 2,100. j. Percent Paid and/or Requested Circulation. Average No. Copies Each Issue During Preceding 12 Months: 83%. Actual No. Copies of Single Issue Published Nearest to Filing Date: 82%. I certify that all information furnished on this form is true and complete. Nancy Rose, Editor.

A Dandy for Winter: *Jasminum nudiflorum*

Jon Hetman

Discovering eye-catching ornamental interest in the winter landscape can be a challenge, but is by no means an impossible task. Some taxa retain their attractive fruits long into winter, and plants with handsome bark like paperbark maple (*Acer griseum*) or colorful stems like red osier dogwood (*Cornus sericea*) stand out like beacons against a snowy backdrop. Truly astonishing, both from a visual standpoint as well as a scientific one, is the odd species that hazards to bloom when most other plants—and indeed most pollinators—lie dormant. *Jasminum nudiflorum*, or winter jasmine, is one such horticultural jewel.

A member of the olive family (Oleaceae), winter jasmine is a hardy member of a genus best known for its potently fragrant tropical and subtropical members. Blossoms of this small deciduous shrub appear before the leaves (its specific epithet means "naked flowers"), borne singly in the leaf axils on the previous year's wood like its relative, *Forsythia*, which it rather resembles. Winter jasmine's small, waxy, bright yellow flowers feature funnel-shaped corollas that flare at the end into five or six spreading lobes, giving a starlike appearance. These are described as either non-fragrant or possessing a delicate, mossy scent, but in any event they do not summon the delightful olfactory sensations that makes its genus name synonymous with perfume. Fortunately this shortcoming is redeemed by an extremely lengthy period of bloom, which may last from November to March. In severe winters, some dieback may occur and flowers may suffer damage, but the plant usually rebounds to continue flowering after such events.

Compounding the seasonal interest offered by its flowers, *J. nudiflorum* also delights with arching, willowy green stems that provide further visual relief from winter's tonal monotony. In spring, stems produce compound leaves that are oppositely arranged and composed of three ovate leaflets, each about ½ to 1 inch (1.3 to 2.5 centimeters) long. Foliage stays a lustrous dark green through the summer and drops in autumn without any appreciable color change. In the wild, plants produce rather inconspicuous black berries, though cultivated plants appear to be self-sterile.

Perhaps unsurprising for a plant that blooms at the most unforgiving time of year, winter jasmine is a fairly tough customer. It tolerates a wide range of both soil and light conditions, though it grows and flowers best in full sun to part shade in well-drained, loamy soil with regular moisture in USDA Zones 6 to 10. Gardeners also appreciate its versatility of form, growing it as a small (3 to 4 feet [1 to 1.2 meters] tall) shrub or spreading ground cover, or even training it up a vertical surface using supports. Its long, arching branches make it a great choice for cascading over a wall or terrace. Winter jasmine displays incredible vigor as a ground cover; its stem tips root readily where they touch the ground, making it an attractive choice for erosion control. It may sprawl aggressively under the right conditions, but cutting it back will both rejuvenate the plant and produce fewer bare patches in subsequent flowerings. No serious insect or disease problems trouble its robust nature.

Native to China, winter jasmine can be found thicketing slopes and ravines in Gansu, Shaanxi, Sichuan, Xizang (Tibet), and Yunnan. The plant was introduced to the West in 1844, and first described by English botanist John Lindley in the *Journal of the Horticultural Society of London* in 1846. It has gained popularity in Europe and North America as an ornamental, even naturalizing in parts of France and the United States. A small number of cultivars have appeared in the trade, notably 'Aureum' with yellow-variegated leaflets and a slow-growing dwarf form called 'Nanum'.

The Arnold Arboretum has grown winter jasmine since 1885, beginning with a cultivated plant attributed to Charles Sprague Sargent, perhaps cut from his own garden. Today, accessions grow in two locations—in the Explorers Garden (603-81-MASS) on Bussey Hill and in the terraces of the Leventritt Shrub and Vine Garden (654-2003-MASS). Seek them in bloom this winter for a delectable foreshadowing of spring.

Jon Hetman is Director of External Relations and Communications at the Arnold Arboretum.